GUIDE

TO THE

CORAL GALLERY

(PROTOZOA, PORIFERA OR SPONGES, HYDROZOA, AND ANTHOZOA),

IN

THE DEPARTMENT OF ZOOLOGY

BRITISH MUSEUM (NATURAL HISTORY),

CROMWELL ROAD, LONDON, S.W.

WITH NUMEROUS ILLUSTRATIONS.

SECOND EDITION.

LONDON:
PRINTED BY ORDER OF THE TRUSTEES OF
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PREFACE.

THE Coral Gallery, the contents of which are briefly described in the following pages, is a long narrow corridor situated between the Bird Gallery and the series of galleries on the north side of the building, being interrupted by three cross-passages between the galleries referred to. The collections exhibited in this gallery include not only the objects commonly recognised as Corals, but also other lower types of animal life scientifically known as *Hydrozoa*, *Porifera* and *Protozoa*, which include jelly-fish and their allies, sponges, and microscopic organisms such as Foraminifera and Radiolaria, which in the remote past have played an important part in the formation of the chalk and limestone rocks of the earth's crust. In giving an account of such objects as these it is difficult to avoid the use of many scientific and technical terms, but an endeavour has been made to make the text as comprehensible as possible to the general public. Much care has been bestowed upon the selection and preparation of the numerous illustrations, many of which are entirely new. The part of the Guide referring to Protozoa, Porifera and Hydrozoa has been prepared by Mr. R. Kirkpatrick and the description of the Anthozoa by Mr. F. J. Bell.

In conclusion, thanks are due to Dr. Gustav Fischer of Jena, to Messrs. F. Warne & Co., Messrs. Cassell & Co., Messrs. Macmillan & Co., Messrs. A. and C. Black, Messrs. J. and A. Churchill, the Royal and the Royal Microscopical Societies for kindly allowing the use of illustrations in various works published by them.

E. RAY LANKESTER.

PREFACE TO THE SECOND EDITION.

AN additional eight pages on the important subject of Sporozoa and certain allied organisms (including the parasites which cause Malaria and Sleeping Sickness) have been inserted between pages 14 and 15, and have been numbered 14A—H; also eight additional figures designated 10A—H have been added.

E. RAY LANKESTER.

TABLE OF CONTENTS.

GUIDE TO THE CORAL GALLERY.

PROTOZOA OR SIMPLEST ANIMALS.

Introduction.

The majority of the Protozoa are extremely small objects, being [illegible] in many cases invisible or barely visible to the naked eye. Consequently, excepting in certain instances, diagrams and models are [illegible] exhibited in place of specimens.[1]

The Protozoa are essentially composed of one "cell." The word "cell" was originally used to describe a vegetable cell or vessel with its walls and fluid contents, just as we speak of a bottle of wine; but now the term is used for the minute corpuscles of protoplasm or living substance which build up animal and vegetable structures.

The Protozoa stand in contrast with all the rest of the Animal Kingdom or Metazoa, the latter being composed of many cells of different kinds united into a commonwealth organised on the principle of division of labour. In the figure of Hydra (p. [illegible]), for instance, we see a sac composed of two layers of "cells," those of the inner layer being concerned in the digestion of food, those of the outer having protective and sensory functions; here each cell is subordinate to the community of cells and cannot live independently. Many Protozoa form colonies, but the individual cells resemble each other, and each cell is independent of the others.

By way of introduction to the subject, a brief description of a Protozoon is given below.

Amœba proteus, or the Proteus Animalcule (Fig. 1), resembles a tiny blob of whitish jelly about $\frac{1}{100}$ of an inch in diameter; it is commonly found at the bottom of ponds on the ooze, where it creeps about in search of food.

The *Amœba*, observed under the microscope, usually seems globular and motionless at first, but presently knobs appear on the surface, some of which enlarge and flow out in the form of finger-like

[1] The diagrams and models exhibited in the Case are referred to in the text as "Plate and Model," with their appropriate number.

High Wall Case E. end of Gallery.

lobes. The lobes are termed "pseudopodia" (*pseudos*, false or apparent; *pous*, foot), because they enable the animal to move about. "In the continual extension and branching of one or more of the chief pseudopods," writes Professor Leidy, "the *Amœba* progresses more or less rapidly, the body appearing incessantly to exhaust itself in the continual growth and elongation of the pseudopods and in the production of new ones, while it is as

FIG. 1.

Amœba proteus, the Proteus Animalcule. Figure on left, small specimen, magnified 250 diameters. Figure on right × 200. *n*, nucleus; *c v*, contractile vacuole; *f*, foreign bodies; *p*, pseudopods. Arrows indicate direction of streaming of pseudopods and of motion of the animal. (After Leidy.)

incessantly replenished by the contraction and melting away of pre-existing pseudopods." The little creature is continually changing its shape, and hence Rösel, who discovered it in 1755, called it "the little Proteus," after the monster of the fable.

When the *Amœba* comes in contact with a Diatom, Desmid, or other object suitable for food, it envelops and ingests it, and, in due time, casts out the indigestible débris.

Food may be taken in and the remains ejected at any point of the surface of the body, but sometimes only over more or less definite areas. The body of the animal is usually crowded with food-balls, shells of Diatoms, cells of green algae, &c.

The protoplasm of the body, with the exception of a thin, clear, outer layer, is granular ; at one part (Fig. 1) is seen a discoid, denser portion of protoplasm, known as the "nucleus." There is also present in the interior of the body a clear spherical vesicle—the "contractile vacuole"—which slowly expands and rather suddenly collapses and disappears, reappearing at the same spot and going through the same cycle. The contractile vacuole is probably an organ for the excretion of waste products. The animal reproduces itself by dividing into two, this process being preceded by division of the nucleus, each half of the *Amoeba* becoming a distinct individual.

Classification.

The Protozoa are divided into two great sections—the Gymnomyxa or Rhizopoda, and the Corticata or Infusoria.

In the first section, the protoplasm of the cell is homogeneous throughout, but in the second the superficial layer is firmer than the more fluid interior portion.

The Gymnomyxa, in their adult phase, move about and obtain their prey by means of pseudopods. The Corticata are provided with flagella or cilia. A classification of the Protozoa (after Prof. Lankester, *Encyc. Britannica*) is given in the "Explanation of Plates" in the Case.

GYMNOMYXA (RHIZOPODA).

For simplification, the Gymnomyxa are here divided into four groups :—

I. Lobosa, with lobose pseudopods.

II. Heliozoa, with fine radiating pseudopods.

III. Foraminifera, in which main trunks of pseudopods branch out into a fine network, and with a shell usually composed of carbonate of lime.

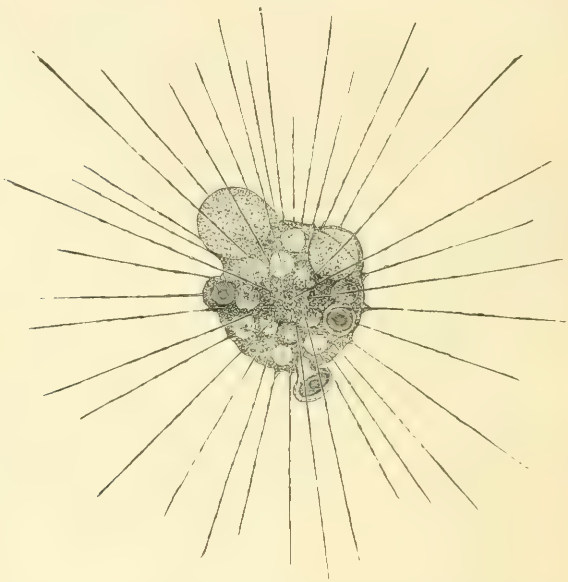
IV. Radiolaria, with a "central capsule," with fine radiating pseudopods, and usually with a shell of silex or horny acanthin.

Lobosa.

High Wall Case E. end of Gallery.

The Lobosa, or Gymnomyxa with lobose pseudopods, may be without shells, as *Amœba* (see Plate III. and Model 1 in the Case), or they may be enclosed in a shell, as, for example, *Difflugia pyriformis* (Model 2) and *Difflugia acuminata* (Plate III. in Case), in both of which the shell is composed of cemented sand-grains. The shelled forms creep about with the shell uppermost and with

Fig. 2.



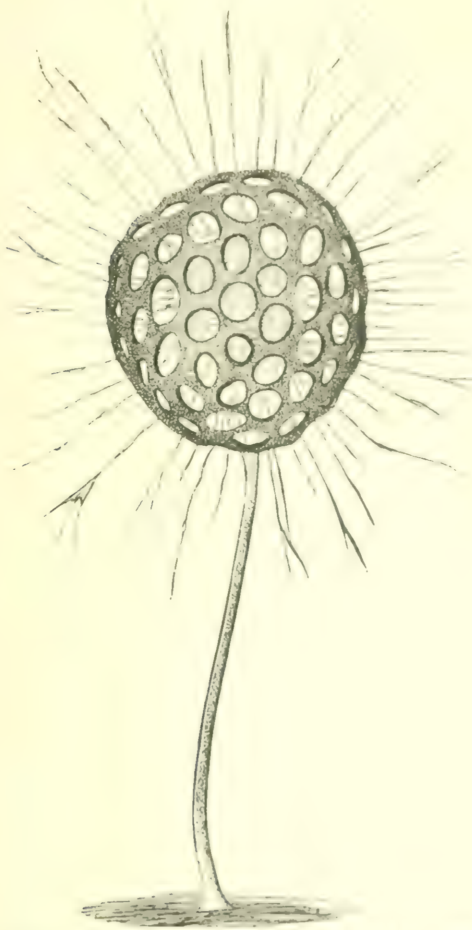
Actinophrys sol, the Common Sun-Animalcule. The large globule projecting from the surface is a contractile vacuole. Magnified 500 diameters. (After Leidy.)

the pseudopods emerging from the aperture below. The Lobosa live, for the most part, in fresh water, damp moss, etc.

The Mycetozoa, or Fungus Animals, which may be conveniently referred to here, are, by some naturalists, regarded as vegetable organisms. In dealing with the lowest organisms, it is often difficult to determine definitely their true position in the kingdom of life, whether they are to be regarded as members of the

animal or vegetable kingdom, or as being in an intermediate position. In some phases of their life-history, Mycetozoa exhibit characters attributed to vegetable organisms; in other phases, again, they

Fig. 3.



Clathrulina elegans, the Latticed Sun-Animalcule.
Magnified 350 diameters.

resemble undoubted animal organisms. One of the best known forms is *Fuligo septica*, which creeps over the surface of tan-pits. The creeping "plasmodium" develops masses of cysts known as

High Wall Case E. end of Gallery.

"flowers of tan." The cysts rupture and liberate *Amœba*-like spores (flagellulæ), which fuse together to form a plasmodium.

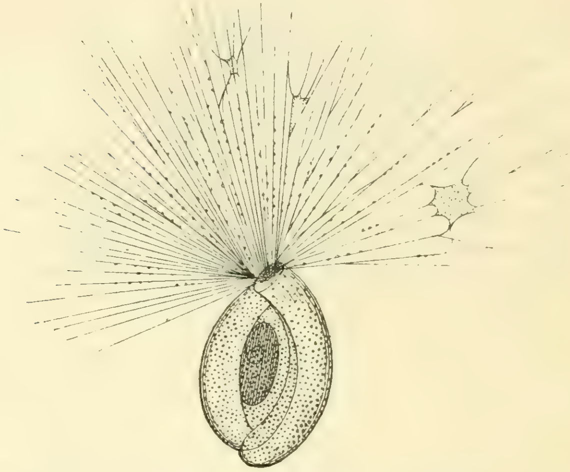
Didymium, one of the Mycetozoa, is figured in Plate II. in the Case.

Heliozoa or Sun Animalcules.

The Sun Animalcules are more or less spherical in form and provided with fine ray-like pseudopods. They mostly inhabit fresh water

Actinophrys sol, the Common Sun Animalcule (Fig. 2), lives

Fig. 4.[1]



***Miliolina tenera*, one of the Imperforate Foraminifera. Young living animal with expanded pseudopods. A nucleus is seen in the innermost chamber. Magnified. (After Max Schultze.)**

amongst weeds in ponds. "It commonly appears as a globular, hyaline, foamy, or vesicular body, bristling with delicate rays, and suspended almost stationary in the water" (Leidy). The total diameter is about $\frac{1}{20}$ of an inch. The body generally contains, in addition to the central nucleus and the contractile vacuole, numerous vacuoles and food-balls : the contractile vacuole is usually seen emerging from a point on the surface, bursting, and reappearing at the same spot (Model 3). *Actinophrys* swims by means of its flexible pseudopods, and when one of these touches some organism, the latter is drawn towards the body and engulfed. Well might

[1] From "Encyclopædia Britannica."

Joblot, who, in 1754, first discovered it floating about in an infusion of celery, speak of it as "the most extraordinary fish one could imagine." A continual streaming of the protoplasm rendered visible by the granules in its substance is constantly proceeding up and down the pseudopods. The little organism reproduces itself by dividing into two (Model 4).

Actinosphaerium eichornii (see Plate V. in the Case) has a spherical body with a well-defined outer zone of large vacuoles; this form, which is also abundant in ponds, somewhat resembles a giant Sun Animalcule, being about five times the size of *Actinophrys*.

Rhaphidiophrys elegans may be either solitary (Model 5), or they form colonies in which several of the spheres are joined by bands (Model 6); numerous slender curved spicules of silex abound in the surface layer of the body and pseudopods.

Clathrulina elegans (Fig. 3), which lives in ponds and ditches, may be compared to a Common Sun Animalcule enclosed in a latticed sphere of silex supported on a slender stalk; the diameter of the shell is about $\frac{1}{600}$ inch, and the length of the stalk about $\frac{1}{100}$ inch. See Model 7 in the Case.

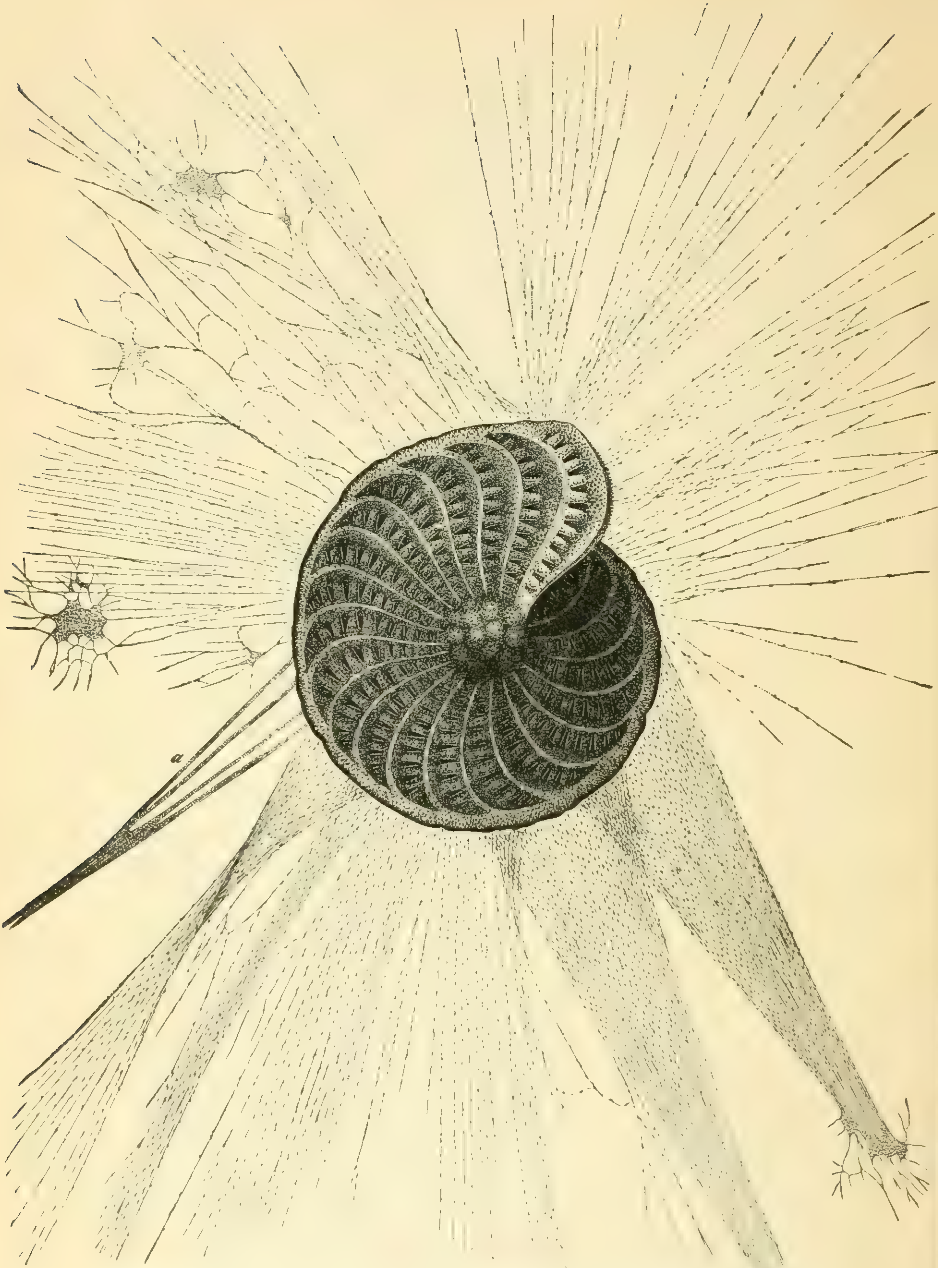
Foraminifera or Reticularia.

The majority of the Foraminifera form a shell of carbonate of lime; in some, the shell is composed of cemented sand, mud, or sponge spicules, and, in a few species, of membrane or silex. The series of Foraminifera mounted on slides is arranged in ten families according to Mr. H. B. Brady's classification, an enlarged figure being placed below each slide. The classified series is preceded by an introductory account of the group. The small plaster models on steps and on the floor-shelf represent selected types, both living and fossil.

When the skeletons of Foraminifera were first discovered, they were supposed to be the shells of tiny Cephalopods or other Mollusca. Great was the sensation in the scientific world when, in 1835, Dujardin found, from observation of the living animals, that the builders of these complicated shells consisted simply of apparently structureless protoplasm, which extruded root-like bundles of branching and anastomosing threads whereby the creatures crept along (Figs. 4, 5). Accordingly he removed these organisms from the Mollusca and placed them in a new group, Rhizopoda (*rhiza*, root; *pous*, foot).

Foraminiferal shells either have only one or a few main apertures

FIG. 5.



Polystomella, one of the Perforate Foraminifera, showing trunks of pseudopods emerging from the shell. Magnified 200 diameters. (After Max Schultze.)

Fig. 6.

A section of Nummulitic Limestone from a Himalayan Peak 19,000 feet above sea-level. Magnified 40 diameters.

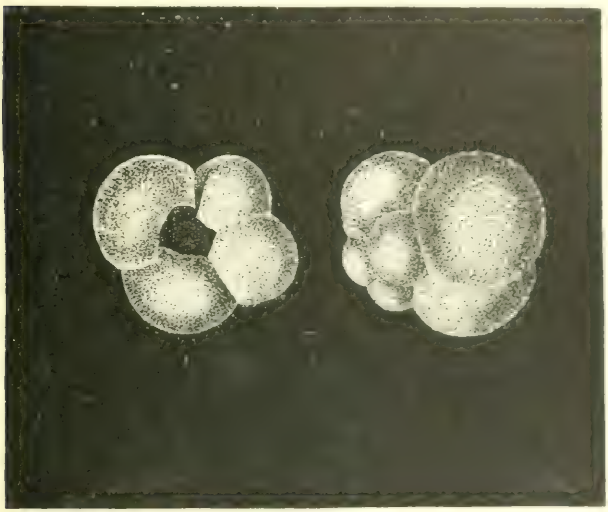
In the upper left corner of the plate are vertical sections (willow leaf pattern), and near the upper right corner a section, in horizontal plane, of *Nummulites*. Distributed over the field are numerous sections of *Miliolina*, *Rotalia*, *Textularia*, &c.

To face p. 9.

(Imperforata, Fig. 4), or have, in addition to the main aperture, the wall of the shell perforated by numerous pores (Perforata, Fig. 5). Calcareous imperforate shells (see Family II.) have an opaque white porcellanous appearance, and perforate shells, in their early stages, a vitreous appearance (Families V. to X.). The shell may consist of one chamber (*Lagena*, Family VII.), or of many, arranged in linear, spiral, or concentric series, or on each side of a middle line.

In *Globigerina*, *Rotalia*, &c. (Family VIII. and IX.), all the chambers of the "rotaliform" spiral are visible from above, but

Fig. 7.



Shells of *Globigerina*, showing lower and upper surface. Magnified.

only the last coil from below. In *Nummulites* (Family X. and Introductory series) the last coil of the spiral wholly encloses all the preceding coils.

Although many of the specimens in the Case are very small, yet, with the aid of the diagrams, the shape can frequently be made out; in some species the shells attain to relatively immense proportions, as *Cycloclypeus carpenterii* (Family X.), from Borneo, with a thin discoid shell over two inches in diameter.

The Foraminifera have played an important part in forming

High Wall Case E. end of Gallery.

the rocks (chalks and limestones) of the earth's crust, and at the present time are covering millions of square miles of the ocean floor with a pinkish-white mud or ooze, formed chiefly of their skeletons. The shells of *Globigerina bulloides* (Fig. 7 ; and specimens and figures in Introductory series), a species which lives at the surface of the ocean, form a large proportion of the ooze, which is hence termed "Globigerina Ooze." The piece of dark-coloured Tertiary Nummulitic limestone (Fig. 6) exhibited in the Case, formed part of the débris from the summit of a Himalayan peak 19,000 feet above the sea-level. The occurrence of this ancient sea-floor in its present position affords clear proof of the elevation of the peak within—geologically speaking—comparatively recent times.

The large plaster models of *Biloculina* illustrate "dimorphism," a phenomenon now found to be of frequent occurrence in Foraminifera, and attributed to alternation of generations.

One of the vertical sections shows a large central chamber (megalospheric form), and the other shows numerous small ones (microspheric form). Parallel series of fossil Nummulites (see Introductory series and Family X.) are often found together in a stratum, disks with small central chambers occurring along with usually smaller disks with large central chambers ; formerly the two kinds were regarded as different species, but are now considered to be different forms of one and the same species.

Radiolaria.

The characteristic feature of the Radiolaria is the presence of a membranous "central capsule" dividing the body into two zones, an intra-capsular zone including the nucleus, and an extra-capsular whence the pseudopods radiate. The vast majority form a skeleton of silex or of acanthin, a horny organic material ; a few species are without a skeleton.

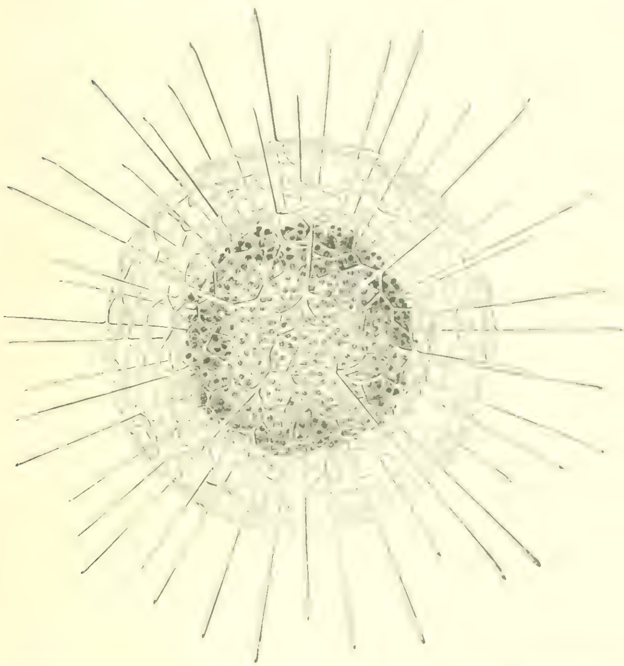
The Radiolaria live in the warmer waters of the ocean, mostly at or near the surface, but some species exist only in the deeper zones. Over vast areas in the tropical Pacific and Indian Oceans, and at depths of about 3,000 fathoms, the ocean floor is composed of an ooze chiefly made up of the skeletons of Radiolaria, and hence termed Radiolarian Ooze. Certain rocks, as, for instance, Barbados Earth, are largely or almost entirely composed of Radiolarian skeletons.

When floating alive at the surface, Radiolaria are often richly

coloured with crimson, blue and yellow tints and have been well termed "gems of the ocean." Their skeletons assume an endless variety of beautiful and curious shapes, such as spiny latticed spheres, rings, beehives, &c. The Radiolaria, of which about 4,000 species have been described, are primarily classified according to the structure of the central capsule, the shape of the skeleton tending to conform, more or less, to the shape of the latter.

Professor Haeckel divides the group into four Orders :—

FIG. 8.[1]



Haliomma wyvillei. Magnified 200 diameters. (After Wyville Thomson.)

I. SPUMELLARIA (Fig. 8, and see Plate VII. and Models [illegible]) in the Case, with spherical central capsule uniformly perforated by pores. Here the skeleton is typically formed of a latticed sphere or of several concentric latticed spheres united by radial beams which do not penetrate the central capsule, and with radiate spines.

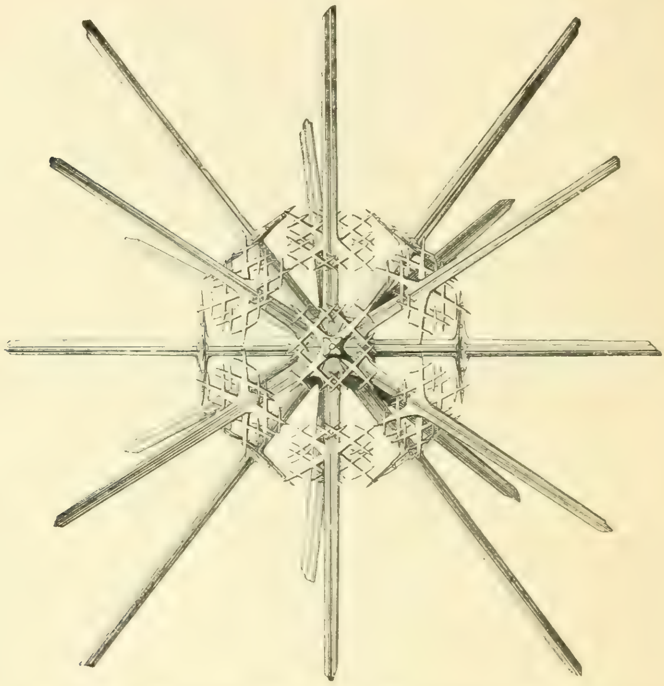
[1] From "The Voyage of the Challenger—Atlantic."

High Wall Case E. end of Gallery.

Spongosphæra (Model 12) has three spheres, the outermost consisting of a spongy reticulum; the fine smooth spines in this model represent pseudopods, but the pseudopod rays are beaded in the other models. *Spongosphæra streptacantha*, which is common on the surface of warm-temperate and tropical seas all over the world, is about $\frac{1}{60}$ of an inch in diameter.

II. ACANTHARIA (Fig. 9, and Model 13), with spherical porous

FIG. 9.[1]



Xiphacantha murrayana. Magnified 100 diameters. Skeleton only. (After Wyville Thomson.)

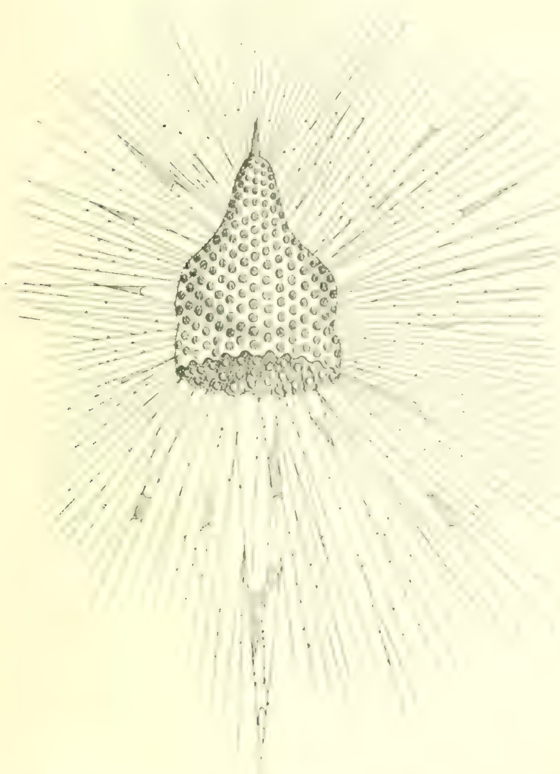
central capsule, with skeleton of "acanthin," constructed of 20 radiate spines proceeding from the centre, and always arranged in fours according to a definite law known as "Müller's Law." The idea of a terrestrial globe with its parallels helps one to realize the plan; thus Haeckel calls the five fours equatorial, tropical and

[1] From "The Voyage of the *Challenger*.—Atlantic."

polar. The radiate spines give off horizontal or tangential spines (Fig. 8) or plates, which may remain separate (Fig. 9) or may fuse to form a* latticed sphere (see Model 13 of *Dorataspis diodon* in the Case).

III. NASSELLARIA. The central capsule is conical, and perforated

FIG. 10.



Eucyrtidium cranioides. Entire animal as seen in the living condition. Magnified 150 diameters. (After Haeckel.)

only by a large opening in the basal region. *Eucyrtidium* (Fig. 10) and *Dictyopodium*, see Models 14, 15 in Case, are beehive-shaped with three segments. The yellow balls situated on the pink central capsule represent a symbiotic Alga, commonly found associated with Radiolaria.

* From "Encyclopædia Britannica."

High Wall Case E. end of Gallery.

Eucecryphalus schultzei has only two segments, the lower being expanded out, and the central capsule is lobed ; see Model 16 in Case.

IV. Phaeodaria (Models 17, 18), with a double-walled central capsule with a few large orifices, and surrounded by dark brown pigment. The skeleton of *Aulosphæra* (Model 17) is formed entirely of tubes of silex, which join to form a spherical lattice with triangular meshes, a tube with verticils of spines radiating from each node. This species, which lives at the surface in the Mediterranean, has a large shell $\frac{1}{12}$ of an inch in diameter.

Aulacantha (Model 18) has a skeleton formed of hollow siliceous tubes of two kinds, viz., radiating spines and loose needles arranged tangentially on the surface.

CORTICATA OR INFUSORIA.

If any animal or vegetable substance be allowed to remain in a vessel of clear water exposed to the air, in a short time tiny specks will be seen swimming about. The organisms appearing in these infusions were termed Infusoria or Infusions Animalcules. The organic matter has simply served as nutriment to the germs of these Animalcules previously existing in the water or in the air. Infusoria abound in fresh and stagnant water and also in the sea.

The organisms grouped under this name differ from the Gymnomyxa, in having, in their adult phase, a dense cortical body-layer and often flagella or cilia in place of pseudopods. A cilium is a hair-like organ which can only bend and straighten itself, and which only acts in unison with other cilia. A flagellum acts independently, and with a lashing to and fro movement.

The Corticata may be roughly divided into four groups : Sporozoa, Flagellata, Ciliata, and Acinetaria.

Sporozoa.

The Sporozoa are parasitic Protozoa which live in the tissue-cells and fluids of other animals. The study of these organisms has of late years acquired an immense importance on account of the wide-spread and dangerous maladies to which some of them give rise in man, domestic animals, fishes, &c. For instance—to mention a few of the more important diseases—the various kinds of malaria in man, Texas fever in cattle, coccidiosis in rabbits and other animals, " psorosperm " disease (myxosporidiosis) in fishes, silkworm disease, and sarcosporidiosis in cattle, are all due to the presence of Sporozoa in the blood

or tissues. Mention may conveniently be made here, also, of Sleeping Sickness and Tsetse disease, caused by the presence in the blood respectively of man and of domestic animals, of a parasite (*Trypanosoma*) belonging to the Flagellata and allied to the Sporozoa.

General Characters of the Group.

Fig. 10a.

Porospora gigantea [illegible] from intestine of Lobster. (After van [illegible] from Lankester.)

The Sporozoa, from their parasitic habit of passively absorbing the juices of their host, lack organs for capturing and digesting food. Usually they are of more or less definite form, and with the cell body bounded by a cuticle. Generally they are stationary, though some move by means of pseudopods (like Amœbæ), and some have flagella during a phase of their life cycle. The most important character, and the one to which the group owes its name, is that of forming spores or germs, which are commonly enclosed each in a tough envelope or cyst (Fig. 10b), and often all the spores formed from one parent cell are enclosed in a common cyst. The conditions necessary for the existence of these organisms are so nicely adjusted that each species of parasite is usually confined to the same or an allied species of host, and to the same tissues of that host.

The Sporozoa may be grouped under the following headings:—(1) Gregarines, (2) Coccidia, (3) Myxosporidia and Sarcosporidia, and (4) Parasites of the blood.

(1) Gregarines. These organisms are of very common occurrence in the intestine and body cavity of invertebrate animals.

Porospora gigantea (Fig. 10a), from the intestine of the lobster, is an unusally large species. Specimens, which may be nearly an inch in length, look like small worms, yet in spite of such huge dimensions they consist of only a single cell with a nucleus. The cell body in this and some other species is divided into two segments, the upper one being small and often modified so as to become an efficient fixing organ.

Monocystis agilis is very commonly found within the sperm sacs of earth worms. The little elongated oval Gregarine lives in its

earliest stage in the interior of a sperm morula (or mother cell which gives rise to the spermatozoa). The parasite grows at the expense of the cell and becomes free of it and actively motile. This is the nutritive or trophic phase, and the organism is termed a trophozoite. The fully-grown trophozoite becomes associated with another like itself, and the two form round themselves a common cyst; the nuclei of each break up, each nuclear particle surrounding itself with a little of the protoplasm of the mother cell, and becoming a sporoblast or gamete. True conjugation now takes place, each gamete of one mother cell

FIG. 10B.

Ripe cyst of *Monocystis agilis*, × 750, showing the spores (pseudonavicellæ) within the cyst. After Lankester.

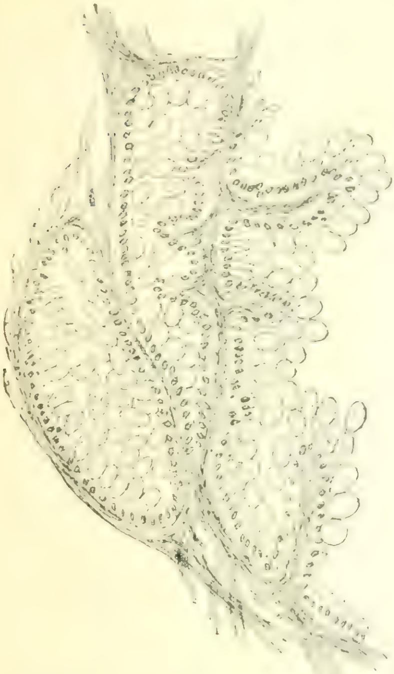
coupling with a gamete of the other, thus forming a "zygote." The zygotes become oval and secrete a tough membrane or sporocyst, thus constituting true spores. Lastly, the protoplasm of the spore divides up into eight sporozoites. Fig. 10B shows a cyst containing oval spores, formerly termed "pseudonavicellæ" because they resemble in shape the Diatom *Navicula*. The spores pass out of the body and are casually eaten by another earthworm; then the spore cyst ruptures and the sporozoites escape and actively burrow through

the intestine till they reach the sperm sacs; each sporozoite attacks a sperm morula and grows into a trophozoite, thus completing the cycle.

(2) COCCIDIA. The Coccidia most commonly attack epithelial cells, such as those lining the intestine or liver cells.

The parasite *Coccidium schubergi*, which is found in the intestine of the centipede *Lithobius forficatus*, grows inside the

FIG. 10C.



Section of rabbit's liver infected with *Coccidium oviforme*. After Balbiani. (From Minchin's Sporozoa, Lankester's Treatise on Zoology.)

FIG. 10D.*

([illegible] parasite on [illegible] *Ect.*, ectoplasm; *ps.*, pseudopodia; *end.*, endoplasm; *y.*, yellow globules; *sp.*, spores with polar capsules. After Thélohan. (From Minchin's Sporozoa, Lankester's Treatise on Zoology.)

infected cell, and at its expense, into an oval or spherical body. When full growth is reached, the parasite undergoes division into a number of small cells (merozoites), each of which becomes free and attacks another epithelial cell, attains maturity, and itself undergoes division, so that at last all the epithelium may be destroyed; but a time comes when some of the merozoites become distinct male and female cells, the male breaking up into male "gametes," each with two flagella, the female remaining as a

* For Fig. 10D see p. [illegible]

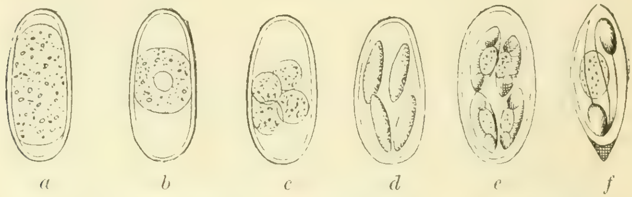
single large cell. When the latter is fertilised by one of the male gametes, the resulting zygote forms round itself a cyst, while the contents break up into sporoblasts, each of which forms a double envelope and becomes a true spore. Lastly, the spores divide, each into two sporozoites.

Fig. 10C. shows a section of the liver of a rabbit suffering from Coccidiosis, due to the presence of *Coccidium oviforme.*

Fig. 10D, *a—e* shows a zygote dividing up into spores, *f* being a spore with two sporozoites.

(3) MYXOSPORIDIA AND SARCOSPORIDIA. Myxosporidia are mostly parasitic in fishes, in which they are commonly situated beneath the epidermis of the gills and fins, and in the wall of the bladder. The body of the parasite is an Amoeba-like cell (Fig. 10E),

FIG. 10D.



Spore formation in *Coccidium oviforme* from liver of rabbit. Highly magnified; *a*, encysted individual (zygote); *b*, zygote contracting to a sphere; *c*, *d*, *e*, division into spores; *f*, single spore, more highly magnified. After Balbiani. (From Minchin's Sporozoa, Lankester's Treatise on Zoology.)

which may multiply by dividing into two, or by forming buds; quite early in life spores are formed in the cell body. The spores contain peculiar pear-shaped bodies, each of which contains a coiled thread. When another animal swallows the spores, the stimulus of the digestive juices causes the extension of the coiled filaments, which thereupon attach the spore to the wall of the gut.

The Sarcosporidia are found parasitic in the striped muscle fibres of cattle and pigs, in which animals multiplication and growth of the parasite often sets up abscesses in the tissues.

(4) PARASITES OF THE BLOOD.

See Models and Diagrams in the Central Hall.

One of the most important discoveries of recent times, and one certain to have extremely beneficial consequences,* has been that of

* On the occasion of the delivery of the inaugural address of Prof. E. A. Minchin, Professor of Protozoology, Sir Lauder Brunton pointed out that the darkness of darkest Africa was probably in no small measure due to the prevalence of biting flies, ticks, &c., infected with Protozoan parasites. Not

the cause of Malaria or Ague. For countless generations man has suffered from this mysterious malady, and innumerable theories, such as its being due to the effects of the bad air—hence the name "Malaria"—of marshes and soils, rapid variations of temperature, heat of the sun, &c., &c., have been brought forward to account for it.

It is only within the last quarter of a century that the real cause has become definitely known. In 1882 Laveran, a French doctor at Algiers, found the blood of patients suffering from malaria infested with an organism to which he gave the name *Oscillaria malariæ*, under the impression that it was a vegetable; and, further, he showed that the symptoms of the patient resulted from the presence of this organism in the blood. Later, the parasite was found to be a Sporozoon, and was named *Laverania malariæ*. The next great discovery was that of the means whereby human beings became infected. The labours of Ross, Grassi, and others showed that the agency whereby the malarial parasite was inoculated into the blood was that of the stab of the blood sucking mosquito, *Anopheles*. It was found that the mosquito was not a mere carrier, but a true intermediate host, in whose body the malarial germs underwent the sexual phase in their life history. A brief account of the life cycle of one of these blood parasites will now be given.

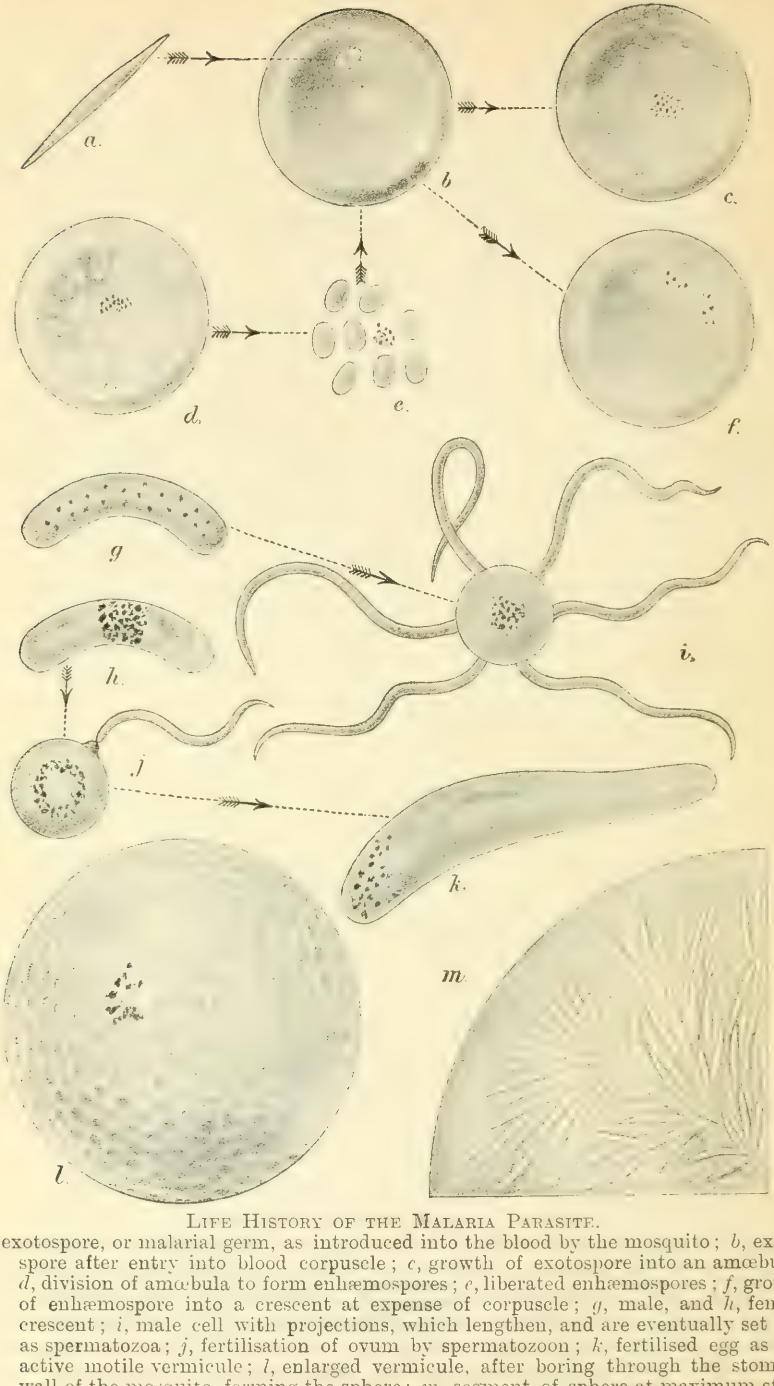
Pernicious malaria is caused by the Hæmosporidian *Laverania malariæ*. An *Anopheles* infected with the germs (exotospores) of *Laverania* stabs the skin of a human being with its piercing and suctorial proboscis. The mosquito pours into the wound a tiny drop of its saliva, which is crowded with the *Laverania* germs.

Each minute spindle-shaped exotospore (Fig. 10F, *a*) attacks and penetrates a red blood cell, and becomes an amœbula, which grows at the expense of the blood cell (Fig. 10F, *b*, *c*); when mature the amœbula divides up into a rosette-like group of "enhæmospores" (Fig. 10F, *d*).

The blood cell breaks down and the liberated enhæmospores (Fig. 10F, *e*) proceed to attack other blood cells within which they grow into amœbulæ, which again divide up into rosettes. In tertian ague, due to *Plasmodium vivax*, this cycle takes forty-eight hours, and the onset of the fever every third day coincides with the liberation of enhæmospores and the attacking of fresh blood cells; in quartan ague, due to *Plasmodium malariæ*, the cycle takes seventy-two hours.

only has Man's life and health been seriously affected, but also civilisation prevented by the extermination of domestic animals. Already, thanks to the labours of men of science, localities formerly pestiferous have become salubrious.

FIG. 10F.



LIFE HISTORY OF THE MALARIA PARASITE.

a, exotospore, or malarial germ, as introduced into the blood by the mosquito; *b*, exotospore after entry into blood corpuscle; *c*, growth of exotospore into an amœbula; *d*, division of amœbula to form enhæmospores; *e*, liberated enhæmospores; *f*, growth of enhæmospore into a crescent at expense of corpuscle; *g*, male, and *h*, female crescent; *i*, male cell with projections, which lengthen, and are eventually set free as spermatozoa; *j*, fertilisation of ovum by spermatozoon; *k*, fertilised egg as the active motile vermicule; *l*, enlarged vermicule, after boring through the stomach wall of the mosquito, forming the sphere; *m*, segment of sphere at maximum stage of development, containing countless needle-shaped spores, which, when it bursts, escape as exotospores into the organs of the mosquito's body and pass through the salivary glands into the proboscis, and so infect a man bitten or pricked by the mosquito. (The figures are taken from enlarged models exhibited in a case in the Central Hall of the Museum.)

The invading enemy is attacked and partly held in check by the white blood cells, which devour and destroy many of the enhæmospores before they become ensconced inside the helpless red blood cells.

If the malaria parasite had to depend on the above asexual mode of propagation by simple division, it would soon become extinct: the host would die, and the parasite also. For the mosquito wholly digests amœbulæ, rosettes, and enhæmospores along with its meal of blood, and accordingly is unable to convey them alive to another host having a fresh supply of blood cells.

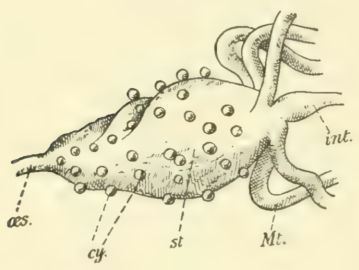
After a certain number of generations of asexual division, however, the full-grown amœbulæ, instead of dividing up into enhæmospores, become sausage-like crescents (Fig. 10F, *f*), some of the crescents being male (Fig. 10F, *g*) and others female (Fig. 10F, *h*), the sexes being distinguished by the mode of distribution of the dark granules (see figures). No further changes take place in the human host, but if an *Anopheles* now sucks the blood, and takes in the malaria germs, the male and female crescents and spheres are not digested, but become spherical and develop as follows: the male spheres suddenly push out projections which lengthen (Fig. 10F, *i*), and very rapidly become free as wriggling spermatozoa; the female cell attracts a spermatozoon, probably by chemical allurement (Fig. 10F, *j*); the two elements fuse and the resulting fertilised egg or zygote becomes an actively motile vermicular cell (Fig. 10F, *k*), which burrows through the stomach wall of the mosquito, where it forms a sphere (Fig. 10F, *l*). The sphere now grows to a considerable size (Fig. 10G, showing many spheres on the wall of the stomach), and its contents break up into sporoblasts, which again give rise to countless spindle-shaped exotospores (Fig. 10F, *m*). The sphere bursts and the exotospores are conveyed into the tissues and organs of the mosquito, many of them coming to rest in the salivary glands, whence they are finally inoculated into a human being when the mosquito stabs the skin; and we now arrive at the point whence we started.

The terrible Sleeping Sickness of man, and the Nagana or Tsetse disease of domestic animals are both due to the presence in the blood of different species of a minute corkscrew-like flagellate organism—*Trypanosoma*—which though mentioned here must be classed with the group Flagellata. The body of the *Trypanosoma* (Fig. 10H) is provided with a fin-like extension, and with a flagellum. As in the case of malaria, there is an intermediate host, the blood-sucking Tsetse fly, which inoculates the *Trypanosoma* into the blood of its

victim. The life history of one of these parasites has been fully worked out by Schaudinn in the case of the Trypanosome (*Trypanomorpha noctuæ*) of the Stone Owl, the other host being the Gnat (*Culex pipiens*). The Stone Owl is tolerant of the parasite's existence, and suffers no harm from its presence. The Gnat is a true host, the parasite undergoing its sexual development in the intestinal tract (see the case and illustrations in the Central Hall).

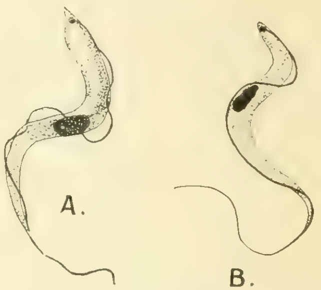
The Sleeping Sickness prevalent in Tropical Africa is set up by the stab of a Tsetse fly (*Glossina palpalis*) infected with *Trypanosoma gambiense*, the fly itself having become infected by sucking the blood of a human victim of Sleeping Sickness, or possibly that of some native tribes who have become tolerant of the existence of the parasite.

FIG. 10G.



Stomach of mosquito with cysts of malarial parasite, × 40. *Oes.*, œsophagus; *st.*, stomach; *cy.*, cysts; *mt.*, malpighian tubules; *int.*, intestine. After Ross. (From Minchin's Sporozoa, Lankester's Treatise on Zoology.)

Fig. 10H.



Trypanosoma gambiense, very highly magnified from human blood. (*A*, after Bruce and Nabarro; *B*, after Castellani. From H. M. Woodcock, Quart. Journ. Mic. Sci.)

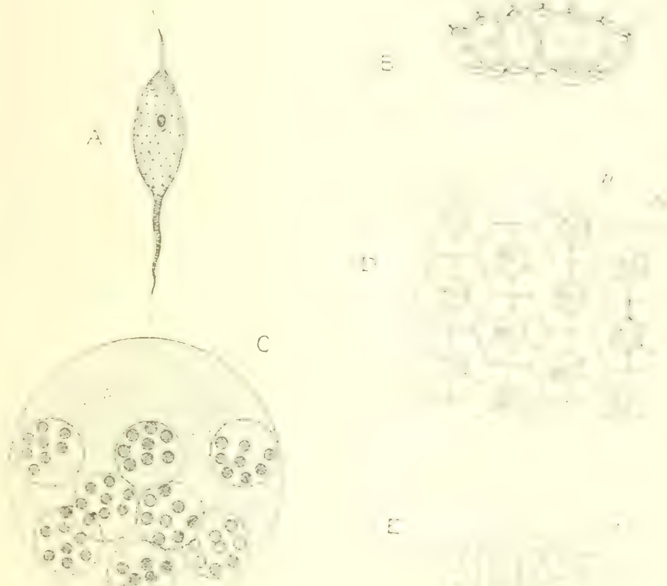
At first the Trypanosome (Fig. 10H) multiplies in the blood, but, later, gets into the cerebro-spinal fluid, where its presence gives rise to the peculiar nervous symptoms of drowsiness ending in coma and death.

The Tsetse disease of domesticated animals is caused by the blood parasite *Trypanosoma brucei*, which is inoculated by the stab of the Tsetse fly (*Glossina morsitans*, and other species). The Tsetse fly itself becomes infected by sucking the blood of wild Antelope or Buffalo, which are tolerant of the existence of the Trypansome in their blood; but imported cattle, as in the case of human beings immigrant in a new region, are not tolerant, and die from the effects of the rapid multiplication of the Trypanosome in their blood. The Tsetse disease is prevalent in S.E. and S. Africa.

FLAGELLATA.

The FLAGELLATA are Corticata in which the cell-body is provided with one or a few flagella. The cell may be solitary (Fig. 11A), or may be joined with others to form colonies (Figs. 11B).

FIG. 11.



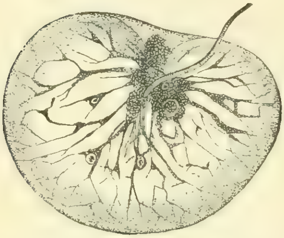
Flagellata. A. *Cercomonas crassicauda*, a unicellular Flagellate (× 2000). B. *Gonium pectorale* (× 325). C. *Volvox globator* with daughter and grand-daughter colonies (× 55). (After Carter.) D. Surface view of *Volvox* showing cells in hexagonal spaces in common jelly; a, flagellum; cv, contractile vacuole. Very highly magnified. (After Bütschli.) E. Vertical section of wall of *Volvox* (× 800). *a*, parts of flagella. (After Cohn.)

Volvox globator (Figs. 11C, D, E, and Plate IX A) is the Volvox, occurs at times in great abundance in ponds, even to the extent of giving a green colour to the water. The little organism, which is about $\frac{1}{50}$ of an inch in diameter, looks like a tiny green speck, moving about in

High Wall Case E. end of Gallery.

the water (in a tumbler). On being magnified, the speck is seen to be a spherical sac uniformly dotted with green points and progressing by a peculiar revolving movement. Frequently the sphere contains several green "daughter" spheres, and these, again, "grand-daughter" spheres. The wall of the sphere is composed of a layer of cells (the separate green points), each provided with two flagella. The cells are embedded in a common jelly, each cell in a separate compartment, but connected with its neighbours by radiating strands. The outer surface of the sphere is covered with a pellicle through which the pairs of flagella penetrate, and the interior is filled with fluid in which daughter colonies may often be seen revolving. In addition to a nucleus and contractile vacuole, the body of each cell contains green chlorophyll granules. The daughter colonies inside the sphere escape in due time by rupture of the outer wall of the parent. *Volvox* is generally regarded by botanists as a plant.

FIG. 12.



Noctiluca miliaris, the Phosphorescent Animalcule. Magnified 150 diameters.

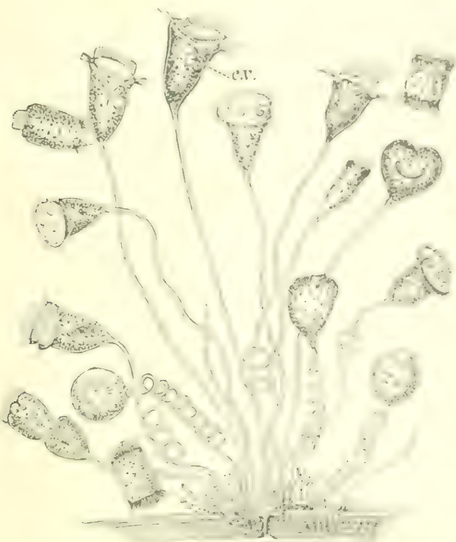
Gonium pectorale (Fig. 11B), a colonial organism belonging to the same family as *Volvox*, forms flat plate-like colonies composed of sixteen cells, each cell having a pair of flagella at its upper end. In one large section of Flagellata the cell is provided at its upper end with a collar, so the flagellum appears to arise from the floor of a basin. *Codosiga cynisca* (Plate IXA. in the Case) forms a branching colony. Some of the collared Flagellates secrete a horny cup or receptacle for the cell, as in the solitary *Salpingœca napiformis* (Plate IXA. in the Case), which forms a stalked horny cup containing the collared flagellate cell. *Proterospongia haeckeli* is a colonial form with *Amœba*-like cells in addition to collared cells, all sunk in a common test. The ancestor of the Sponges, which are unique among the Metazoa in possessing collar-cells, was probably a collared Flagellate. The *Mail Coated Flagellata* have a flattened body, with a longitudinal groove from which a large flagellum projects, and usually, in addition, a transverse groove with a flagellum lying in it. These forms are mostly marine and often phosphorescent. Some species which have a cuticular shell of cellulose, and which contain chlorophyll, are claimed by botanists as plants, but there are closely allied species without the cellulose investment or the chlorophyll. *Ceratium tripos*

(Plate X. in the Case) has a flat triangular body with a spine at each angle. The two grooves form an inverted T-shape, the vertical bar being very broad. The presence of cilia in the transverse band in Plate X. is incorrect, there being simply a single flagellum lying in the groove. Central Gallery.

Ceratium is phosphorescent, and in the open ocean is often found united into chains of two to twenty individuals.

Noctiluca miliaris (Fig. 12) is a little peach-shaped organism about $\frac{1}{50}$ of an inch in diameter. A thick transversely-striated "big flagellum" springs from the bottom of a deep groove on one

FIG. 13.



Vorticella nebulifera, a colonial Bell-Animalcule. (Magnified.) *c.v.* contractile vacuole.

side of the body. Near the groove is the mouth leading into a cylindrical throat, in which is placed a second and smaller flagellum. The body is invested by a firm cuticle, and the protoplasm in the interior is vacuolated. See Plate XI. in the Case.

Noctiluca is highly phosphorescent, the light emanating chiefly from the protoplasm just beneath the cuticle.

Marine phosphorescence is sometimes due entirely to the presence of myriads of *Noctiluca*, which may be present in such abundance

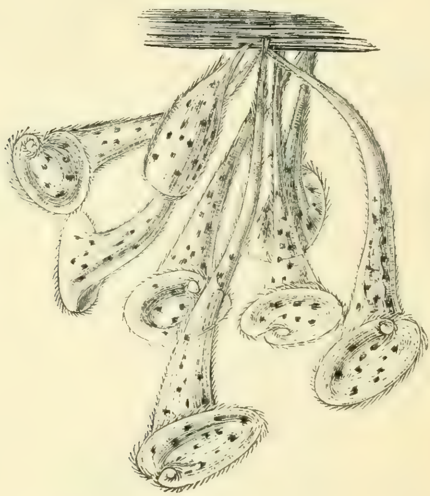
High Wall Case E. end of Gallery.

as to give a reddish colour to the surface of the sea in daytime. In the Persian Gulf, a richly pigmented variety occasionally forms on the surface of the sea brilliant scarlet bands, which extend for many miles.

Ciliata.

The members of this group are characterised by the presence of cilia on the surface of the body. These organs may form a spiral coil round the anterior end of the body in relation to the mouth, or they may be distributed over the whole or part of the surface of the body. *Carchesium polypinum* (Plate XII. in the Case), which belongs to the group of "Bell Animalcules," occurs in ponds in the form of bluish

Fig. 14.



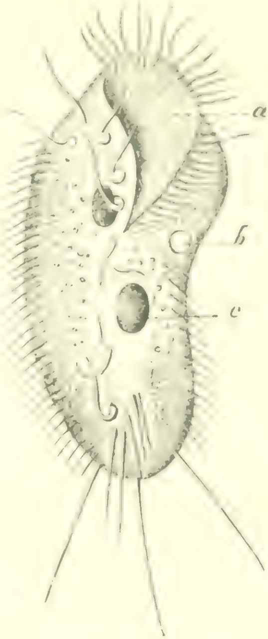
Stentor polymorphus, the Trumpet Polypus. (Magnified.)

mucilaginous filmy patches on fresh-water plants, pieces of wood, &c. The branching fan-shaped colony is highly contractile, and shrinks into a spherical ball on being alarmed. Each individual has a bell-shaped body seated on a stalk. The cilia, which form a spiral fringe round the anterior end, set up a vortex in which food particles are carried through the funnel-like mouth and gullet situated inside the rim, and thence into the interior of the body. *Vorticella nebulifera* (Fig. 13) also forms colonies; the figure shows the individuals in various phases of contraction. Some species of Bell Animalcules are solitary and do not form colonies. *Stentor*

polymorphus, the Trumpet Polypus (Fig. 14), has a trumpet-shaped [illegible] body of green colour, about $\frac{1}{[illegible]}$ of an inch in length, and is commonly to be found singly or in groups attached to the surface and to duck-weed, sticks, &c.; when swimming, the organism changes its shape considerably, becoming ovoid or pear-shaped. The cilia are uniformly distributed over the whole surface, but form a spiral fringe of long cilia round the anterior edge. See Plate XIIA., 2, in the Case.

Paramecium aurelia, the Slipper Animalcule (Plate XIIA., 1, in the Case), has an oval flattened body with cilia uniformly distributed over the whole surface. *Stylonychia* (Fig. 15) has cilia only on the under surface of the flattened body; the thick spine-like organs are peculiarly modified cilia by means of which the organism can stalk about.

Fig. 15



Stylonychia mytilus, the Mussel-Animalcule. Magnified [illegible] diameters. *a*, mouth; *b*, contractile vacuole; *c*, nucleus.

ACINETARIA.

The body, in this group of Corticata, is provided with tentacle-like organs in place of cilia and flagella. *Dendrosoma radians* (Plate XIII. in the Case) is a fresh-water Infusorian of rather large size, attaining a height of $\frac{1}{10}$ of an inch. A fixed stolon gives rise to branching trunks; each branch terminates in numerous suctorial knobbed tentacles, which act by plunging into the bodies of their prey and sucking up the protoplasm. In the young stage, *Dendrosoma* is free and provided with cilia, which disappear when the animal becomes fixed.

PORIFERA [SPONGES].

[The High Cases are indicated by Roman numerals and the shelves of the same by Arabic numerals.]

INTRODUCTION.

High Cases I.–VI. and Table Cases 1 and 2 A, B.

The term "sponge" is popularly associated solely with the soft elastic bath sponge, but a glance at the Cases will show that, in zoology, the word has a much wider meaning, some "sponges" being of stony hardness, others leathery, others again like spun glass.

In life, the bath sponge is tough and fleshy, and covered with a black skin (Case I., specimen in fluid). A section (Fig. 18) shows a light-coloured flesh in which no trace of the horny skeleton, commonly known as the sponge, is apparent; to obtain this the skin and flesh are macerated off, leaving the more resistant SKELETON.

It would be instructive here to notice the glassy skeleton of *Euplectella aspergillum*, or Venus' Flower-Basket (Cases III. 2), and a complete specimen of the same in fluid (Table Case 2A); here again the skeleton is concealed by the soft tissues. The dried specimen of *Euplectella imperialis* (Case III. 3) shows the fluffy-looking soft tissues above and the denuded skeleton below.

Many specimens, especially those in Cases IV.–VI., do not materially differ, excepting in colour, from their appearance in life.

The position of Sponges in the Animal Kingdom is above the Protozoa or Simplest Animals and near the Cœlentera (Zoophytes, Corals, &c.).

To give some idea of the structure of a sponge, a brief account is given of *Halichondria panicea*, the Crumb-of-Bread Sponge, common round the British coast (Case IV. 3).

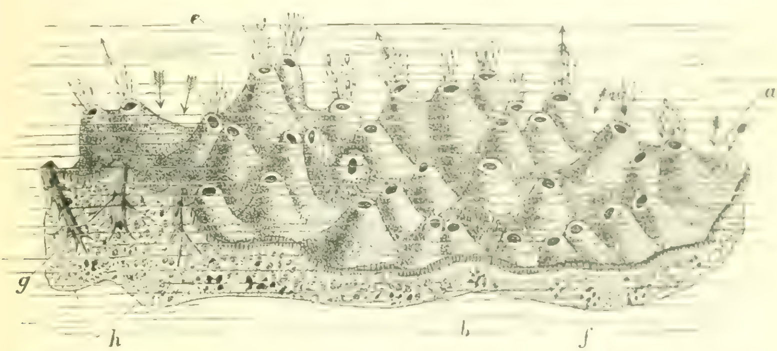
This sponge forms yellow or greenish crusts on rocks, or shapeless masses round the stems of sea-weeds. The surface of incrusting specimens is usually covered with crater-like orifices termed oscules. On closely observing living specimens in a large vessel of sea-water, currents, rendered visible by débris, will be seen coming out of the oscules; a little indigo or carmine will serve to render the currents still more apparent.

FIG. 1.

Aphrocallistes vastus, a Dictyonine Sponge. ([illegible])

The origin of these sponge fountains had always been a profound enigma, which Dr. Grant quaintly compared to that of the then mysterious sources of the Nile. In 1826 the above-named zoologist observed small particles being carried by currents through minute PORES in the general surface of the *Halichondria* (Figs. 2, 3B); and on account of the presence of these pores, he gave the name *Porifera* to sponges. So much for the entrance and exit of currents: to ascertain their complete course and their cause, it is necessary to cut very thin slices of the sponge (Fig. 3). The pores (Fig. 3B) lead into spaces and channels, which are more or less branched, and which finally arrive at the outer surface of groups of spherical cavities termed flagellated or whip chambers, each [illegible] of an inch in

FIG. 2.

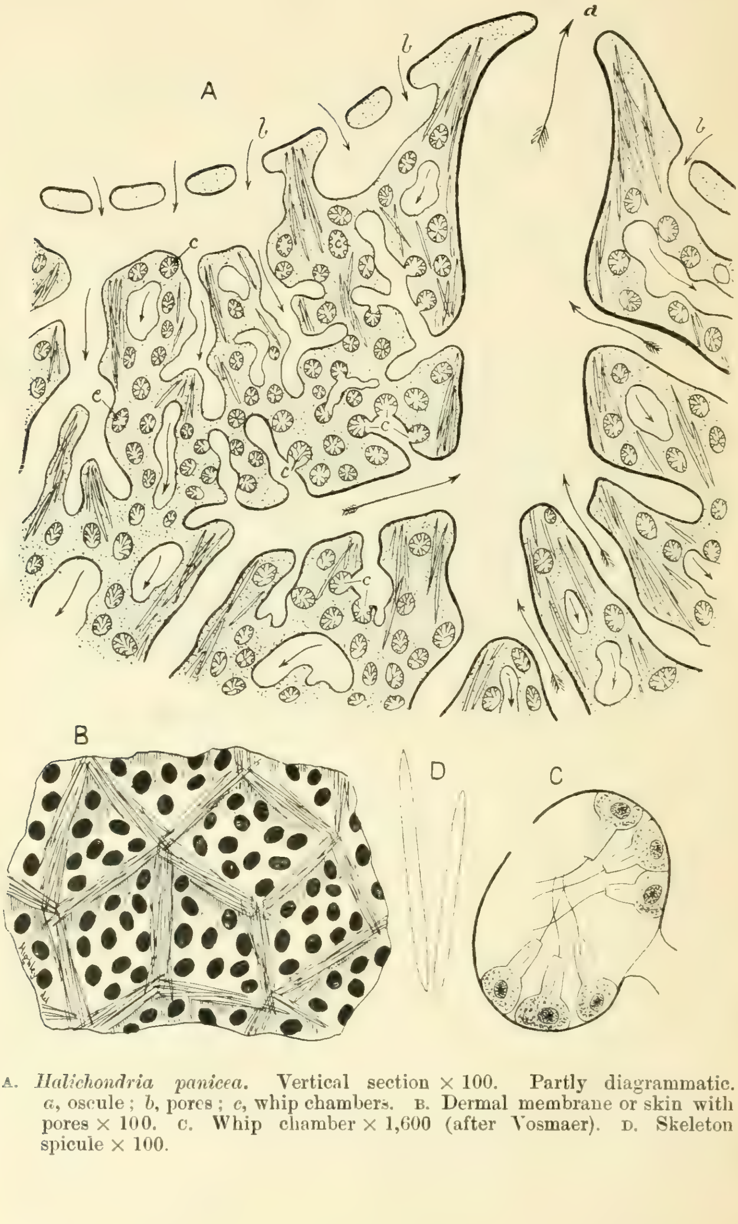


Halichondria panicea (after Dr. Grant). *a*, pores; *e*, oscule; *f*, ova. The outward arrows show the currents escaping by the oscules, the inward ones water entering the pores.

diameter, and with minute orifices in their walls. The whip chambers open each by a comparatively large orifice into channels or spaces; these join with others to form larger and larger canals, which terminate in an oscule. The whip chambers are lined with "collar-cells" (Fig. 3C), each of which is provided with a flagellum or whip and a hyaline collar; the beating of the whips sets up the currents, which bring in food-particles and oxygenated sea-water, the used-up water and débris being driven out through the oscules. Food-particles are taken up bodily by the cells lining the walls of the canals and by the collar-cells; but not much is known on this subject at present. The CANAL SYSTEM from the pores to the whip chambers is termed "in-current," and that from the whip chambers to the oscules "out-current."

High Cases I.–VI. and Table Cases 1 and 2 A, B.

FIG. 3.



A. *Halichondria panicea*. Vertical section × 100. Partly diagrammatic. *a*, oscule; *b*, pores; *c*, whip chambers. B. Dermal membrane or skin with pores × 100. C. Whip chamber × 1,600 (after Vosmaer). D. Skeleton spicule × 100.

The body substance, which is permeated by the canal system, thus contains in the present species minute needles of silex (Fig. 3b), each $\frac{1}{50}$ of an inch in length, scattered rather irregularly throughout the body tissues, but sometimes forming an obscure scaffolding. In the skin, the needles are joined into bundles, which unite at their ends to form a network, in the meshes of which are groups of pores. The body-tissues are composed of cells of various kinds, some of which are concerned in nutrition, others in secreting the skeleton; others, again, line the surface of the canals and of the body.

At certain seasons the body develops egg-cells, which, after fertilisation, form little oval ciliated embryos; these swim about for a day or two, settle down, and become sponges, the ciliated cells becoming collar-cells. The organism, being unable to roam in search of food, sets up currents which convey food to it.

Halichondria is a Siliceous Sponge belonging to the order Monaxonida, because its skeleton is composed solely of siliceous spicules having one axis.

A very brief account of one of the simplest sponges may help further to elucidate the structure of these organisms. The Calcareous Sponge, *Clathrina blanca* (Fig. 4) and Case 2A, in its earliest stage forms a minute thin-walled sac opening at the summit by the oscule. The interior of the sac is lined with collar-cells, and the wall is perforated by fine pores. Currents enter through the pores and leave by the oscule. The thin wall is supported by three-rayed spicules of carbonate of lime. The canal system is here in its simplest form. In *Sycon ciliatum* (Table Case 2A) the wall of the sac gives off horizontally arranged tubular pockets, which alone are lined with collar-cells. A piece of the inner wall of the large specimen of *Sycon ramsayi* (2A) shows the honeycomb-like openings of the tubes.

CLASSIFICATION.

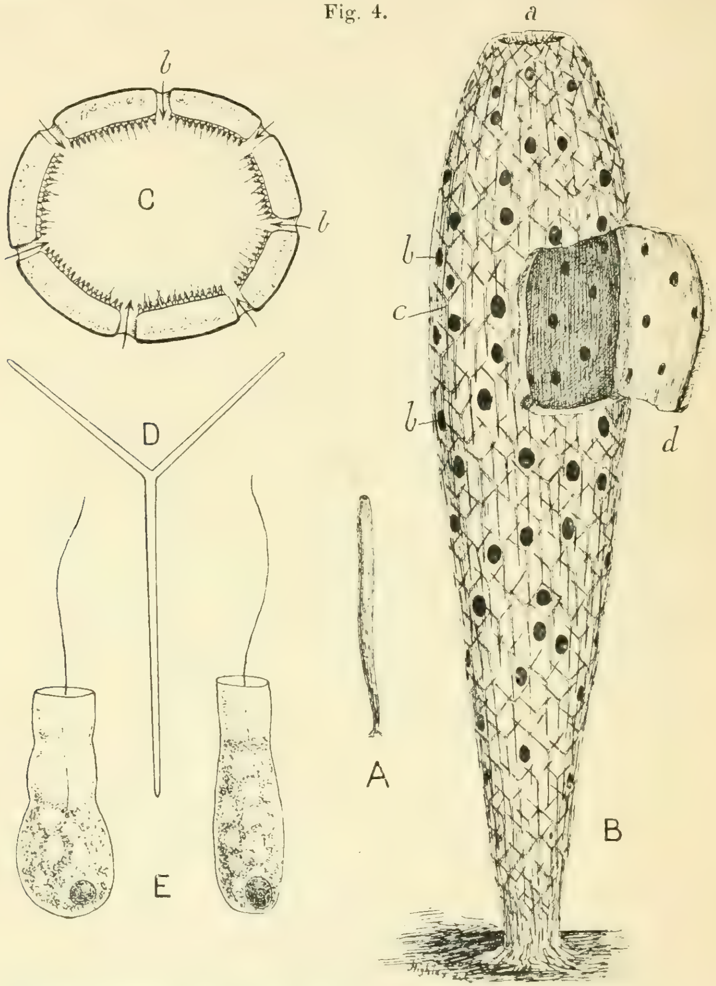
The composition and structure of the skeleton afford the most reliable characters for the classification of Sponges. The skeleton is composed either of calcium carbonate, silica, or horny material usually in the form of fibre. The calcium carbonate and silica are, for the most part, secreted in the form of SPICULES, which may be separate or fused together. A few sponges do not form a skeleton. A simple scheme of classification is given below: –

Class I. CALCAREA. Calcareous Sponges. Skeleton calcareous

High Cases I.-VI. and Table Cases 1 and 2 A, B.

Class II. SILICEA (*silex*, flint). Skeleton siliceous, horny, or absent.

Fig. 4.



A. *Clathrina blanca* × 20. B. The same × 80 (partly diagrammatic). *a*, oscule; *b*, pores; *c*, spicules; *d*, portion of wall turned back. C. Transverse section of sponge (diagrammatic). D. A three-rayed spicule × 300 diameters. E. Collar cells × 1,200 diameters. (After E. A. Minchin.)

NOTE.—In Fig. B, the spicules ought not to have been drawn close up to the margin of the oscule; also the figure is too broad and the pores far too large.

Sub-Class I. HEXACTINELLIDA (*hex*, six; *aktis*, ray). Six-Ray or Glass Sponges. Siliceous spicules typically with three axes and six rays.

Sub-Class II. DEMOSPONGIÆ (*demos*, multitude), including all the sponges other than Calcarea and Hexactinellida.

Grade I. TETRACTINELLIDA (*tetra*, four; *aktis*, ray). Four-Ray or Anchor Sponges. Siliceous spicules typically with four axes and four rays; also certain fleshy sponges (Carnosa) are included here.

Grade II. MONAXONIDA (*monos*, single; *axon*, axis). Monaxon Sponges. Siliceous spicules rod- or pin-shaped.

Grade III. KERATOSA (*keras*, horn). Horny Sponges. Skeleton of horny fibre.

Grade IV. MYXOSPONGIDA (*myxa*, slime). Slime Sponges. Without a skeleton.

CLASS I. CALCAREA [CALCAREOUS SPONGES].

The Calcareous Sponges form a comparatively small group, only about 200 recent species being known. They live for the most part in shallow water, and prefer shady sheltered localities.

The skeleton is composed of spicules of carbonate of lime, which are either separate, or, in a few instances, fused into a solid framework. The spicules are either three-rayed, four-rayed, needle-shaped, or, in one instance, spherulitic.

The *Asconidæ*, which are the simplest of all sponges, are formed of thin-walled branching tubes, lined with collar-cells throughout their inner surface. The tubular branches may be separate (*Leucosolenia*), or may join to form a network (*Clathrina*).

In the *Syconidæ* the collar-cells are restricted to "radial tubes" surrounding a central cavity devoid of collar-cells.

The beautiful Ciliated Sycon (*Sycon ciliatum*) is one of the commonest sponges round our coasts, where it is found attached to rocks and seaweeds. This sponge, which is usually about an inch in height, has the form of a little oval white sac with a silvery crown of spicules round the orifice (oscule). The crown of spicules is fully expanded when currents are passing through, but otherwise it is closed. The wall of the sac is formed of horizontally arranged closely-packed tubes each opening by a comparatively wide aperture into the vertical central cavity, but ending blindly on the outer surface of the sponge. Currents pass through microscopic orifices in the walls of the radial tubes into the interior of those tubes and into the central cavity, and finally leave through the oscule.

A very large specimen of a Sycon Sponge, over eight inches in length, from Poole Harbour, is exhibited in the Case.

Table Case 2A. The Compressed Grantia (*Grantia compressa*), which forms compressed sacs resembling little paper bags, is also common round the British coast.

Sub-Class I. Hexactinellida [Six-Ray or Glass Sponges].

High Case III. Table Case 2 A, B.

The Hexactinellida, which include many remarkable and beautiful forms, nearly all come from great depths, ranging from 90 to 3,000 fathoms.

The skeleton is built up of siliceous spicules, each typically possessing three axes and six rays, or of spicules derived from this type; three bars of equal length crossing each other at right angles through a common centre would give the typical form of a regular six-rayed spicule. Endless modifications of this form occur; the rays may be curved or branched, or one or more of the rays may disappear, giving rise to five-rayed, four-rayed, three-rayed, two-rayed, or one-rayed forms (Fig. 7). The spicules may be roughly grouped into two kinds—large "skeleton" spicules, which form the bulk of the framework, and scattered flesh-spicules of microscopic size.

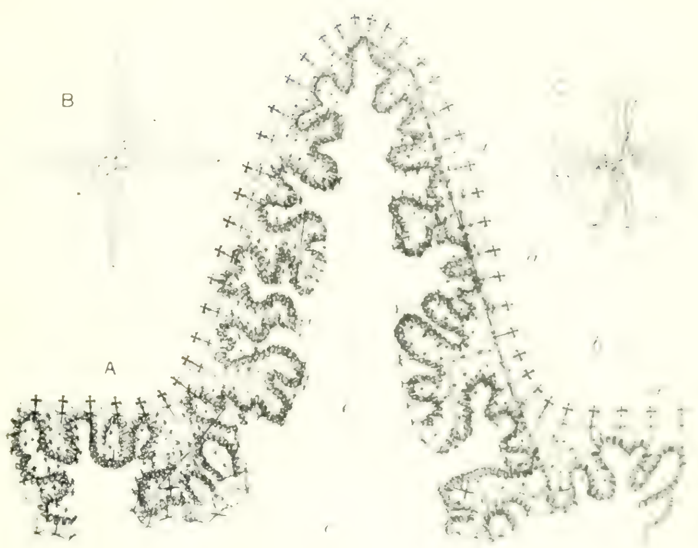
The soft tissues are arranged as follows: in the wall of a typical cup-shaped Hexactinellid, a layer of relatively large thimble-shaped whip chambers is separated from an outer dermal and an inner gastral membrane by loose reticulate tissue. Currents always enter by the dermal membrane, pass through the convex surfaces of the whip chambers, and leave through the gastral membrane. The large central cavity, so often present, is termed the gastral cavity. Hexactinellida are divided into two sub-orders.

Sub-Order I. Lyssacina. In this group the skeleton spicules are separate throughout life, or, in cases where they are more or less fused in later life, were separate in early stages.

Euplectella aspergillum, or Venus' Flower-Basket (Figs. 5, 6; and specimens in Case III. 2, and Table Case 2A), forms an elegant cornucopia-shaped skeleton, now often seen as an ornament. In life the skeleton is concealed by a gelatinous flesh. The lattice-like framework of the skeleton is formed of longitudinal, transverse and oblique strands, the last forming the prominent ridges on the surface; the strands are built up of the fused rays of very large four-rayed and three-rayed spicules. At the lower end is a matted tuft of spicules, by means of which the sponge is rooted in the mud. A surface layer of separate sword-shaped spicules, each with its handle tipped with a lovely little

Fig. 5.

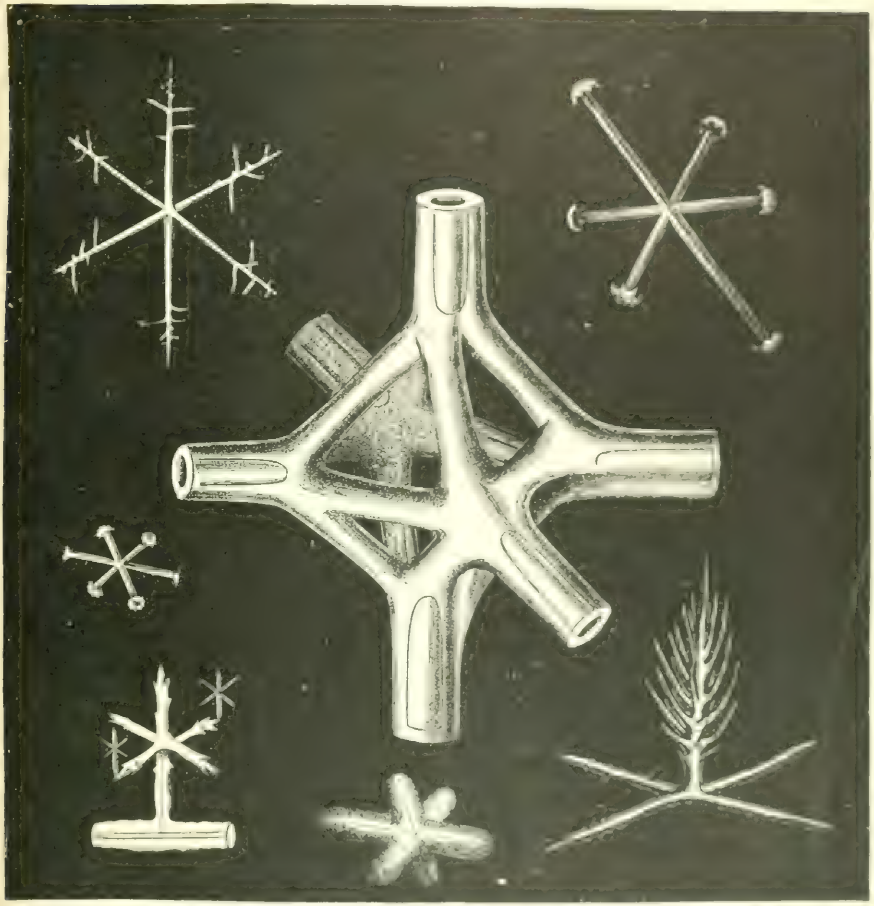
Euplectella imperialis (to the left) and *E. aspergillum* (Venus' Flower Basket)
(One-sixth natural size.)



Euplectella aspergillum. A. Section of a ridge and part of wall [illegible] layer; *b*, flagellated chambers; *c*, gastral cavity [illegible] spicules each tipped with a floricome [illegible] Regular [illegible] C. Floricome spicule × 300. (After F. E. Schulze.)

"floricome" spicule, is characteristic of Euplectellid sponges (Fig. 6). The peculiar circular holes in the wall of the sponge allow of direct communication between the outside and the interior. The large

FIG. 7.

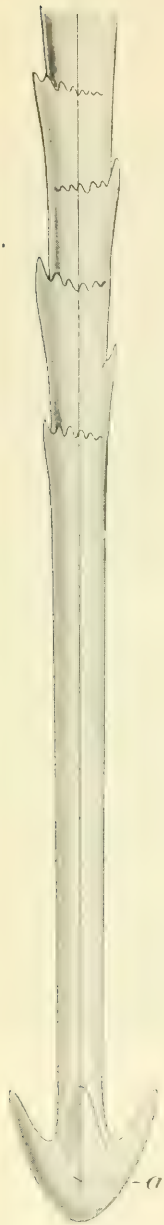


Spicules of Glass Sponges (magnified). In the centre a node of the Dictyonine network of a Ventriculite Sponge.

gastral cavity is closed at the summit by a sieve-plate. *E. aspergillum* is obtained from a depth of 90 fathoms off Cebu, Philippines. The magnificent *Euplectella imperialis* (Fig. 5) and specimens fro

High Case III. Table Case 2 A, B.

Fig. 8.



Lower end of a spicule of the glass rope magnified. *a*, axial canals of five aborted rays.

Case III. 3) comes from Japan. Specimens of the two species have been photographed together for comparison.

The fine specimen of *Walteria leuckarti*, from Sagami Bay, Japan (Fig. 9; and Case III. 3), consists of a long hollow thick-walled tube rising from a solid base, and with solid pinnate branches arising from the tube at right angles; the oval sharp-edged openings in the wall of the tube are oscules. The little elevations on the surface of the branches are caused by a commensal zoophyte. *Rhabdocalyptus victor* (Fig. 10) and specimen in Case III. 3, from the same locality as the previous species, forms a deep thin-walled vase of felt-like texture.

The beautiful Lace Sponge, *Semperella schultzei* (specimens in Case III. 1, and Table Case 2B), has a straight or curved conico-cylindrical body terminating below in a massive root-tuft. The surface shows a delicate gauze-like network, the dermal membrane (Fig. 11), and also long bands and patches of coarser pattern; the latter are sieve-plates covering the oscules. In place of a simple central cavity with one terminal oscule and sieve-plate, as in Venus' Flower-Basket, there is a main central cavity giving off lateral branching tubes, the surface-openings of which are covered with the sieve-plates; accordingly currents enter the fine gauze-like areas and leave by the coarser sieve-plate areas.

Hyalonema sieboldii, or the Glass-rope Sponge (Figs. 8, 12) and specimen in Case III. 3, comes from Japan, closely allied species, however, being widely distributed. When the glass ropes (without the upper portion of the sponge) first arrived in Europe, they were supposed to be either artificial productions or the axial core of Gorgonid Corals. The twisted strand or glass rope is a root-tuft composed of immensely long spicules, which root the sponge in the mud, and which, at the upper end, project like a spike into the interior of the sponge-body. Some of the long spicules end in a toothed disk, and are provided along their length

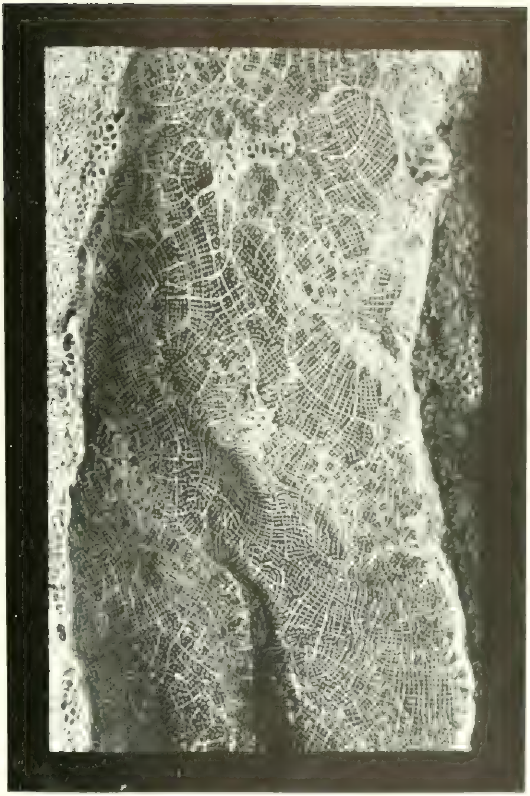
FIG. 9.

Walteria leuckarti. An Euplectellid Sponge. [illegible]

FIG. 10.

Rhabdocalyptus victor. A Lyssacine Sponge. (One-fifth natural size.)

FIG. 11



Surface network of *Semperella schultzei*, the Loom-sponge.
(Natural size.)

FIG. 17

Hyalonema sieboldii, the Glass-Rope Sponge. (One-fourth natural size.)

NOTE.—A crust of *Palythoa*, a zoophyte associated with this sponge, had unfortunately become detached from the upper end of the "Glass-rope," and is not shown in the illustration.

with a serrated spiral ridge with the teeth pointing upwards [illegible] (Fig. 8).

The body of the sponge forms a thick-walled cup, which, however, is so loosely constructed that light can be seen through it. The interior is divided up by four to eight vertical partitions radiating from a central spike. The top of the cup is closed by a thin sieve-plate with perforated "quarters" corresponding to the divisions inside. A "commensal" zoophyte (*Palythoa*) is always found investing the upper end of the glass rope, and occasionally it forms pits (often mistaken for oscules) on the surface of the sponge itself. Unfortunately the *Palythoa* has become detached from the upper part of the root-tuft of the specimen figured, but is abundant on the surface of the sponge body. The Japanese deep-sea shark-fishers obtain the sponge by means of hooks attached to their deep-sea lines. By a curious parallel, the deep-sea shark fishers of Portugal obtain a nearly allied species of *Hyalonema* in somewhat the same manner.

Lophocalyx philippinensis, from Cebu (in Hall, Table Case [illegible]), which forms a small compact thick-walled cup with long root-tufts, furnishes a beautiful example of bud formation, buds of all ages being present on the specimens.

Sub-Order II. Dictyonina. In this group the skeleton, even in the earliest stages, forms a rigid framework constructed of the fused rays of large regular six-rayed spicules. These sponges usually have a vitreous, finely honeycombed appearance. The magnificent *Aphrocallistes vastus* (Fig. 1), in the centre of Case III., is shaped like a vase with a thick stem, and with large folds projecting out from the walls. The very fine specimen of *Chonelasma calyx*, to the right of the former, is bowl-shaped, and with finger-like pockets often extending down, like the "roots" of a Banyan tree, till they reach the base on which the sponge is growing. The fossil Ventriculites common in flints from the Chalk are Dictyonine Sponges.*

CLASS III. DEMOSPONGIÆ OR COMMON SPONGES.

The Common Sponges include all sponges other than the Calcareous and Glass Sponges.

Tetractinellida (Four-Ray Sponges).

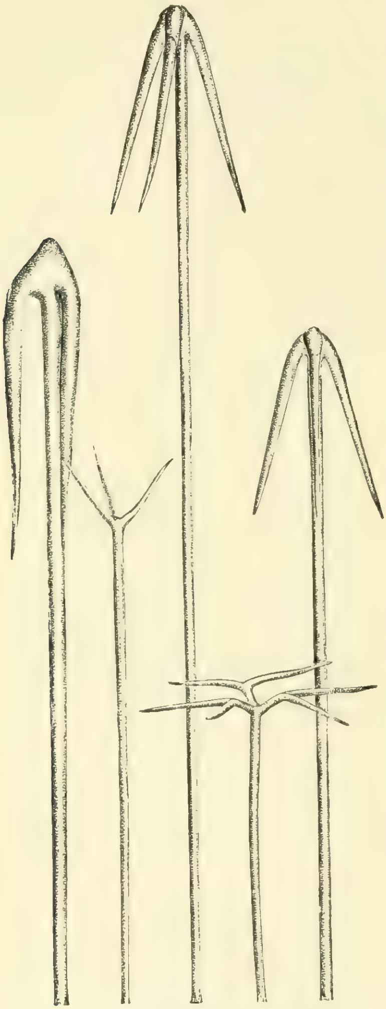
The sponges of this Order are often spherical with a radiating structure (*Craniella*, IV. 3), or they may form tough leathery masses [illegible] High Case IV.

* A later classification of Hexactinellida by Prof. F. E. Schulze is into two sub-orders, (1) *Hexasterophora* [illegible] spicules, and (2) *Amphidiscophora* [illegible] Case X, columns 6 and 7.

High Case IV. Right Partition.

with a conspicuous rind (*Cydonium japonicum*, IV. 4), or rigid plates or masses of stony hardness (*Corallistes bowerbanki*, IV. 4). The Order is divided into two groups, the *Choristida* with separate spicules, and the *Lithistida* with peculiar "desma" spicules, which are usually articulated to form a rigid stony skeleton. Some species possess "caltrop" spicules, with four axes and four rays. The most characteristic spicule, however, is the trident, with a long shaft and three prongs, which may project forwards or be bent backwards or outwards (Fig. 13). The tridents are arranged with the shafts pointing inwards and the prongs spreading tangentially beneath the surface or projecting outwards. Tridents and needles in varying proportions often form thick radiating bundles.

Fig. 13.



Trident spicules of Tetractinellid Sponges. (Magnified 200 diameters.)

The Geodine Sponges (*Geodia, Cydonium*) possess a thick outer crust or rind, composed of solid globular spicules (Fig. 14). The "desmas" of Lithistid Sponges are formed by the deposition of concentric layers of silica round a minute rod or caltrop; on this nucleus there arise nodulated branches, which articulate with the branches of other desmas to form a rigid framework. In addition to the "skeleton" spicules, there occur in this Order very minute **S**-shaped, spiral, and stellate flesh-spicules, which are of great aid in determining the affinities of the various species.

Carnosa or Flesh Sponges.

The sponges of this small group either have no hard skeleton at all (*Chondrosia*), or merely scattered stellate spicules (*Chondrilla*). They possess a well-marked rind enclosing a softer "pith," and the canal system is highly developed.

Chondrosia reniformis, or the Sea-Kidney (Case IV, 30), has [illegible]

Fig. 14.

Section of *Geodia* showing crust of globular spicules, radiating bundles of tridents and needles, and small star-shaped flesh spicules. Magnified [illegible] diameters. (After Bowerbank.)

smooth rounded surface, on which one or two small crateriform oscula are present; the numerous pores are not visible to the naked eye. The sponge, being devoid of a hard skeleton, shrinks greatly when dried, but swells up again on being immersed in fluid. Apart from the absence of trident spicules and of a hard skeleton, the Carnosa show many affinities with the Four-Ray Sponges.

Monaxonida (Monaxon Sponges).

High Cases IV.-VI.

This Order contains by far the largest number of species. The skeleton-spicules are uniaxial, *i.e.*, shaped like rods, like needles pointed at one or both ends, or like pins; six-rayed and four-rayed spicules never occur. The spicules may be scattered or united into bundles, and may form radiating or reticulate scaffoldings. Flesh-spicules may or may not be present, one of the most common forms being buckle-shaped (Fig. 17). The huge Neptune's Cup Sponges, *Poterion patera* (on pedestals), from the East Indies, are among the largest of Sponge forms; the skeleton is composed of a dense network of bundles of pin-shaped spicules.

The large specimen of *Poterion* placed above the Hexactinellid Case, and formed of three trays one above the other, belongs to a closely allied species.

The Boring Sponges, which also have pin-shaped skeleton spicules, are remarkable for their habit of boring into shells and limestone.

Cliona celata (Case IV. 3) is very common in oyster shells, in which it excavates extensive lobed galleries; the oscules and groups of pores are situated on conical elevations which project through small holes in the surface of the shell. Vigorous specimens burst through the shell and form large cork-like masses (Case IV. 3), the identity of which with the boring portion was for a long time unsuspected. The magnificent specimen of *Caulospongia verticillata* (Fig. 15; Case IV. 2) has a thick main stem branching into three, the stems giving rise to closely-set whorls (or spirals) of thin lamellae gradually diminishing in size from below upwards.

The massive *Suberites wilsoni* (Case IV. 3) is remarkable for its brilliant purple colour. The colouring matter forms a rich purple solution in acidified alcohol. *Esperiopsis challengeri* (Fig. 16), from 825 fathoms, east of Celebes (specimen in fluid, Case IV. 4), one of the "Challenger" treasures, has a main stem giving off along one edge a series of stalked bowl-shaped fronds increasing in size from below upwards. The in-current pores are situated in the concavity, and the minute oscules on the convex surface of each bowl.

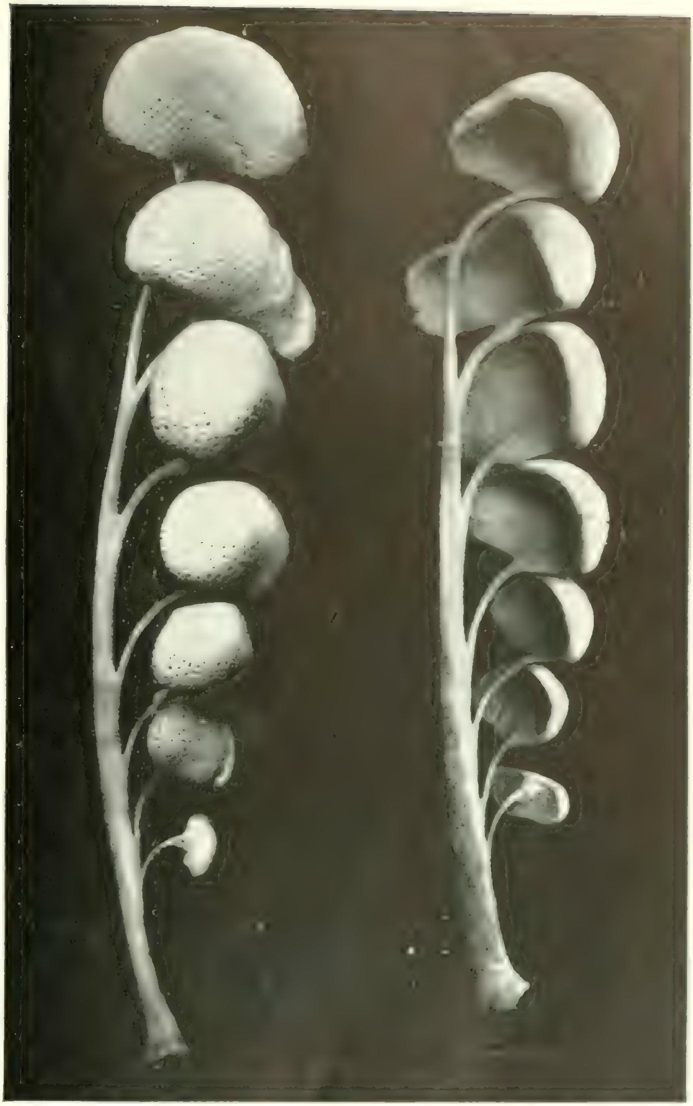
The series of specimens of *Echinonema typicum* (Case IV. 4) shows well the great variation in form that may occur in one and the same species.

Fresh-water Sponges (Case VI. 3, facing west) are common

FIG. 14.

Caulospongia verticillata. A Monaxonid sponge. [illegible]

FIG. 16.



Esperiopsis challengeri. A Monaxonid Sponge. (Two-thirds natural size.) The figure on the left shows oscular, and that on the right pore surface of the sponge leaflets.

FIG. 17.

Siliceous spicules of Monaxonid Sponges.

High Cases IV.–VI.

in lakes and rivers attached to stems of reeds or the piles of locks, &c. These sponges are often of a bright green colour, and are easily mistaken for waterweeds. The green colour, which is due to the presence of chlorophyll, does not occur in specimens living in shady places, the sponges then being pale buff. Alcohol dissolves out the colour, forming a clear green solution.

Spongilla lacustris forms green crusts from which long digitate branches arise.

The black *Parmula batesii* (Case VI. 3), from the Amazons, is often found attached to branches of trees submerged during the rainy season, the sponges being left high and dry when the floods subside.

Many fresh-water sponges produce little seed-like buds or gemmules, which possess a hard resistant capsule perforated by a pore at one point. When the favourable season arrives, the contents of the gemmule burst through the pore and develop into a sponge.

In the Chalinid Sponges (Cases V., VI.), the skeleton forms a network of horny fibres cored by siliceous spicules ; if the latter were absent from the fibres, the sponges would be Horny Sponges, and it is generally supposed that the pure horny sponges have been derived from siliceous forms which no longer secrete silex.

Keratosa (Horny Sponges).

High Cases I. II. and Table Case 1.

The Horny Sponges possess a skeleton of horny fibres, which generally form a close network, as in the Bath Sponges, or the fibres may branch in a tree-like manner. Very commonly, foreign bodies, such as sand grains, the spicules of other sponges, &c., are present in the body of the sponge or in the axis of the fibres ; even in the finest bath sponges there are scattered sand grains in the main fibres.

A series of commercial sponges is set out in Case I. and Table Case I.

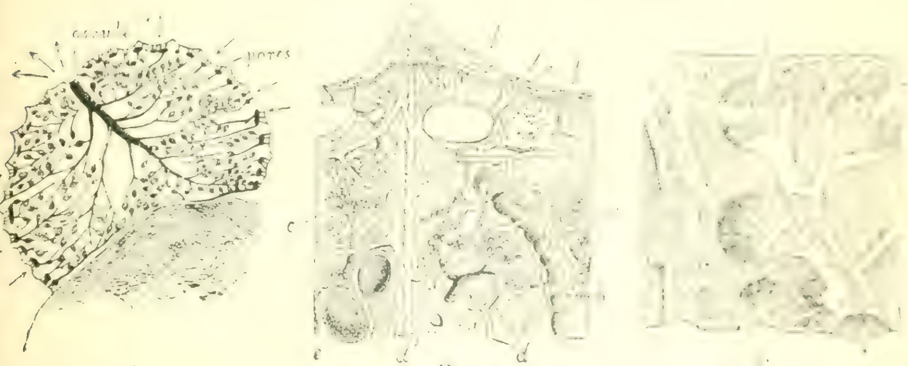
The Fine Turkey Sponge, *Spongia officinalis* (Fig. 18), has a cup-shaped body with a black or dark skin. The oscules are situated on the floor of the cup. A section of the body shows a comparatively uniform pale yellow surface, the canals being slightly darker in tint. Groups of pores on the outer surface lead by short fine canals into spaces just below the skin ; from the floor of these spaces canals pass inwards, branching and gradually diminishing in size, till they reach groups of pear-shaped whip chambers, with the cavities of which they communicate through minute orifices in the walls of the latter.

Groups of whip-chambers lead each to a short [illegible] common channel, which joins with other canaliculi to form canals, finally opening by the oscules. The whip-chambers form a sort of cordon between the extreme [illegible] of the in-current and out-current canals.

The horny skeleton, which is imbedded in and which supports the tissues of the body, forms a network composed of radiating main fibres connected by a dense meshwork of finer secondary fibres.

The Common Bath Sponge, *Hippospongia equina*, has a massive cake-shaped body covered with black or dark skin. The body is permeated by wide channels and cavities separated from each other by

Fig. 18.



A B

Toilet Sponge. A. Diagram of Canal System. B. Section showing *a*, pores; *b*, canals; *c*, whip-chambers; *d*, skeleton fibres; *d'*, main fibre [illegible]. C. Whip-chambers. Highly magnified. (After F. E. Schulze.)

thin walls. The Common Bath Sponge is, in fact, composed of contorted lamellae separated by labyrinthine spaces (Fig. 19); the large holes on the surface are not oscules, but "pseudoscules," the true oscules and groups of pores being scattered indiscriminately over the surface of the lamellae or walls of the spaces. Currents always come out of a true oscule, but they may enter or leave by the holes on the surface of the Common Bath Sponge. See specimens in fluid in Case I.

On the floor of Case I. is a broken pitcher with the skeletons of a bath sponge and fine toilet sponge growing on it.

The *Spongia zimocca*, or Hard Sponge, which forms a third [illegible]

High Cases I. II. and Table Case 1.

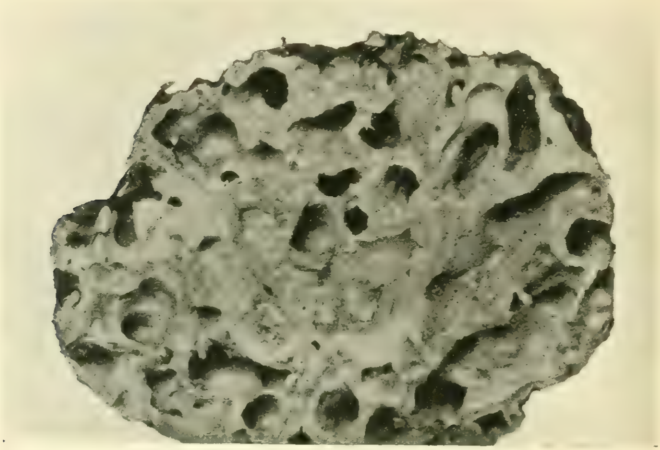
of commercial sponge, has a flat disk-shaped body with numerous oscules on the upper surface.

The Levant Lappet, which is a variety of *Spongia officinalis*, forms huge thin flaps like an elephant's ear; occasionally the edges of the flap unite to form a capacious funnel-shaped cup.

The above three species (*S. officinalis*, *S. zimocca*, and *H. equina*) include numerous varieties and variations which need not be further alluded to here.

Commercial Sponges flourish in sub-tropical and tropical waters in depths of 2 to 100 fathoms, the world's supply coming almost entirely

Fig. 19.



Section of *Hippospongia equina*, the Common Bath Sponge. (Natural size.)

from the West Indies and eastern half of the Mediterranean. In the latter region they are collected by divers, who descend naked or in diving-dresses, or by men who hook up specimens by means of a long harpoon; dredges are employed in deeper waters. In the West Indies (Florida, Bahamas, &c.) the hooking method is employed, a bucket with a pane of glass in the bottom being used as a submarine spy-glass to do away with the effect of the surface ripples.

Sponges are prepared for market by macerating them in sea-water in staked enclosures; after a few days the skin and flesh rot off, and can then be beaten out; the skeletons are hung up in strings to dry and bleach in the air and sun.

Sponges are sometimes cultivated from cuttings, care being taken to ensure that a portion of the skin is retained on each piece. It takes about seven years for a cubic inch of sponge to grow to a marketable size.

Attention is directed to the gigantic *Luffaria archeri* Neptune's Trumpet (Case II.), from Yucatan, and to the fine fan-shaped specimen of *Ianthella flabelliformis* beneath it (Case II.); the horny fibres in these sponges are comparatively thick and cored with a thick pith, those of the bath sponges being solid, or with only a slender core of pith. The specimen of *Phyllospongia foliascens* (Case II. 4) shows a curious likeness to a Turbinarian coral, the oscules of the sponge resembling the calicles of the coral; but it is uncertain whether these resemblances have any real significance.

Myxospongida or Slime Sponges comprise a small group characterised by the entire absence of a skeleton. *Halisarca* forms yellowish-brown slimy crusts on stones.

[A series of specimens and diagrams illustrating the structure of Sponges is exhibited in an upright table case at the eastern end of the Coral Gallery.]

HYDROZOA.

[(*) An asterisk against names of species denotes that specimens in fluid are exhibited in the upright part of Table Case 3.]

INTRODUCTION.

The exhibited collection of Hydrozoa occupies Cases 2–4 at the eastern end of the Coral Gallery.

The members of the class occur as fixed plant-like forms often of horny texture (*Sertularia*, &c., Case 3), or as massive or branched coral-like growths (*Stylaster* and *Millepora*, Cases 2, 4), or as transparent free-swimming bell- or disk-shaped organisms, which may be simple (*Medusæ* or Jelly-Fish, Case 3), or may form colonies composed of variously modified individuals (*Siphonophora*, Case 3). The vast majority of species are marine, but a few live in fresh water.

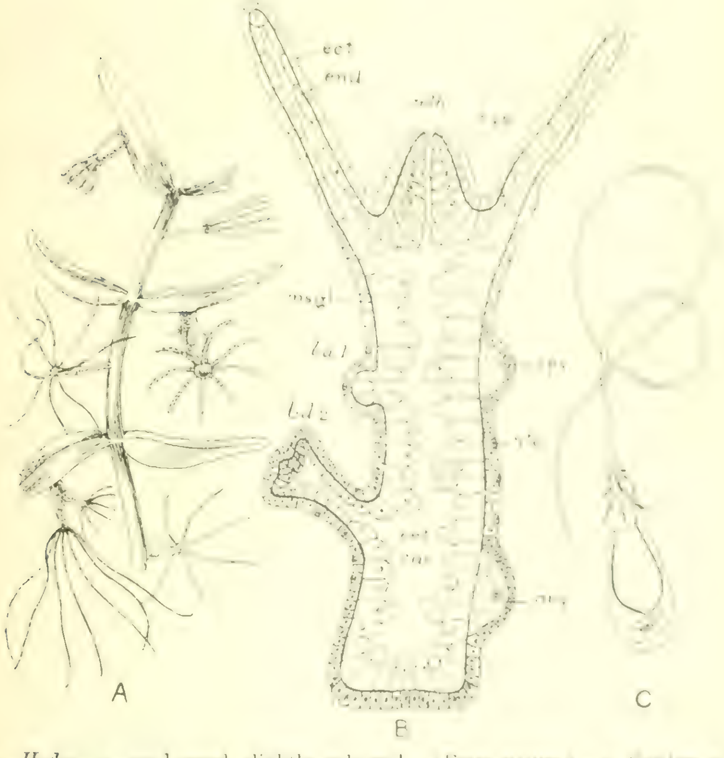
The specimens in Case 3 A, B, closely resemble dried seaweeds, but can generally be distinguished from plants by observing, especially with a lens, that a serrated appearance of the branches is due to little horny cups or receptacles ; see, for instance, *Diphasia tamarisca*,* which has unusually large cylindrical cups. In life, each cup contains a polyp with a crown of tentacles surrounding a mouth opening into a stomach cavity.

In spite of great differences in form amongst the Hydrozoa, a comparatively simple plan of organisation can be traced in all.

To briefly explain this, an account is given of *Hydra* or the Fresh-Water Polyp, a tiny Hydrozoon which lives in ponds attached to water-weeds (Fig. 1A). *Hydra*, which is green or reddish-brown in colour, according to the species, attains an average height of about one-third of an inch. The little creature alters its shape considerably, being now contracted down to a lump, now expanded into a little column with a circle of thread-like tentacles near the summit. When a tentacle touches some small organism, the latter is paralysed and drawn into the mouth at the top of the column, and thence into the simple stomach-cavity, where it is digested, the remains being evacuated by the mouth. Between the mouth and

the circle of tentacles is an area termed the hypostome (Fig. 1). The animal is a simple sac, the wall of which is formed of two layers of cells, an outer or ectoderm layer, one or many cells deep, and an inner or endoderm layer, one cell deep (Fig. 1B, ect, end), the layers being separated by a thin structureless lamella (Fig. 1, msgl).

Fig. 1.



A. *Hydra* on pond weed, slightly enlarged. (From nature.) B. Section of *Hydra*, highly magnified. *mth*, mouth; *hyp*, hypostome; *ent cav*, stomach; *end*, endoderm; *ect*, ectoderm; *msgl*, structureless lamella; *bd 1, 2*, buds; *ovy*, ovary; *spy*, spermary; *ntc*, thread cell. (After Parker and Haswell.) C. Thread cell, very highly magnified. (After F. E. Schulze.)

The endoderm, which lines the whole inner cavity and the interior of the tentacles, is concerned in the digestion of food. In the ectoderm are certain peculiar cells, each containing a cyst with a barbed thread coiled up inside (Fig. 1C); a pointed process projecting from the outer surface of the cell acts as a trigger, which

on being touched, causes the barbed thread to be everted, thereby stinging and poisoning the prey. Thread-cells are characteristic of the Coelentera. *Hydra* reproduces itself sexually by means of eggs, which form in little wart-like swellings on the surface ; or asexually, by forming buds which grow out from the wall, develop mouth and tentacles, and normally become detached. *Hydra*, which is named after the monster of the fable, can be cut into pieces, and, conditionally on containing a portion of the two cell layers, each fragment will develop into a complete animal.

Classification.

Having given a brief outline of the structure of one of the simplest forms, an account will now be given of the groups of Hydrozoa, which, for convenience of description, will be referred to under the three headings :—

I. Hydroida (Hydroid Zoophytes).

II. Hydrocorallinæ (Coral-like Hydrozoa).

III. Medusæ and other allied free-swimming forms (Jelly-Fish, Siphonophora, and Ctenophora or Comb-Jellies).

I. HYDROIDA (HYDROID ZOOPHYTES).

Case 3. The horny plant-like growths in Case 3 A, B, have fundamentally the same structure as the *Hydra*. If the little sac were to form a horny protective cover on its surface, to become longer, to give off buds, which likewise budded, all the buds remaining in connection with each other, and each surmounted by its crown of tentacles—a plant-like Hydroid colony would be the result. *Bougainvillea fruticosa** (Figs. 2, 3, and specimen in Case 3) is a branching Hydroid colony, every branch terminating in a *polyp*, as each individual of a colony is termed. All the polyps are vitally connected with each other by the common living tissues inside the stems. The polyps are of two kinds, one kind being in the form of an elongated sac or tube with a crown of tentacles, that is to say, like *Hydra* ; while the other, when mature, resembles a small Medusa or Jelly-Fish. The Medusa-like polyp (Fig. 4) ultimately becomes detached and swims away. The little free-swimming polyp, which we must now call a Medusa, is bell-shaped ; the true mouth, which leads into the stomach, is at the end of the clapper (manubrium) hanging down from the centre of the

concavity of the bell or "umbrella"; four radial canals pass from base of the central stomach to open into a circular canal round the margin of the umbrella; from the same margin are suspended four pairs of tentacles, each tentacle being provided at its base with an eye-spot. The opening of the umbrella is partly closed by a narrow annular band, the veil or velum, extending in from the rim; and, most important of all, the eggs are situated in the walls of the manubrium. The organism swims by alternate contraction and relaxation of the umbrella.

The little Medusa is simply an extremely modified polyp, specially

FIG. 2.[1]

Colony of *Bougainvillea fruticosa*, natural size, attached to the underside of a piece of floating timber. (After Allman.)

adapted for a free-swimming existence. If a *Hydra* were shortened and drawn out laterally (Fig. 5), a shape somewhat like that of a Medusa would result. The Medusa has nervous and muscular apparatus and sense organs in correspondence with its active existence, these being absent in the fixed polyps.

A colony of *Bougainvillea*, then, is made up of individuals of two kinds, feeding or nutritive polyps, whose function it is to obtain and digest food for the colony, and generative polyps, whose function it is to form and carry the eggs. Here we have division of labour, and

[1] From "Encyclopaedia Britannica."

Case 3. corresponding alteration of form (dimorphism) among the units of the colony.

The fertilised egg of the Medusa develops into the fixed Hydroid colony, the latter forming buds in which the eggs are produced. This is an instance of alternation of generations, a phenomenon very common among the Hydrozoa, but especially marked in cases where the asexually formed generative polyp or individual becomes detached and swims away.

FIG. 3.[1]

Portion of a colony of *Bougainvillea fruticosa*, magnified. (After Allman.)

In cases where the generative polyps are free-swimming, advantage would result from the eggs being scattered over a wide area, and not crowded in the neighbourhood of the parent stock ; and, further, the egg-carrying polyp (Medusa) can swim to the surface where food is plentiful. The free generative polyp, or Medusa of *Clavatella prolifera* (Fig. 6), shows a transition between a feeding polyp and Medusa. The umbrella can scarcely be said to exist in this case, the

[1] From "Encyclopædia Britannica."

Medusa being unable to swim, but only capable of creeping about by means of its peculiar tentacles.

Free-swimming generative polyps or Medusæ occur only in some Hydroids; in many species the generative polyps remain on the colony and produce the eggs in this situation; in such cases they lose, to a greater or less extent, their Medusan structure and may be reduced to a mere wart (Fig. 7).

Generative polyps may arise from the stem as in *Bougainvillea*, but very commonly they arise from the sides of a degenerate feeding polyp which has lost its mouth and tentacles, and is then termed a blastostyle; the latter, with its buds, may be naked (*Hydractinia*, Fig. 9), or invested with a horny capsule (*Sertularia*, Fig. 12 B *b*).

The Hydroida are divided into two groups—Athecata and Thecaphora.

Fig. 8.

Free generative polyp or Medusa of *Bougainvillea fruticosa*. *a*, manubrium; *b*, radial canal; *c*, velum; *d*, tentacles. (After Allman.)

ATHECATA (or *Gymnoblastea*—*Anthomedusæ*). In this group the feeding polyps cannot be withdrawn into horny cups, and the generative polyps or buds are not enclosed in horny capsules. The Medusæ (Anthomedusæ) form the eggs in the walls of the manubrium. *Tubularia indivisa*,* or the "Tubular Coralline like Oaten Pipes" of Ellis, forms clusters of simple stems from six to twelve inches in height, rising from a twisted mass of roots. Each stem, in life, is crowned with a red flower-like polyp with two sets of filiform tentacles, one set being near the mouth and the other at the base; festoons of stalked generative polyps or buds hang down from the base of the feeding polyp. Each bud contains a degenerate Medusa, which never escapes to lead a free life, but produces the eggs in its attached situation. The fertilised egg develops into a peculiar embryo, which becomes fixed and grows up into a long-stemmed polyp.

*Tubularia larynx** has branched annulated stems. The apparent branches on *T. indivisa* arise from embryos settling on the older stems.

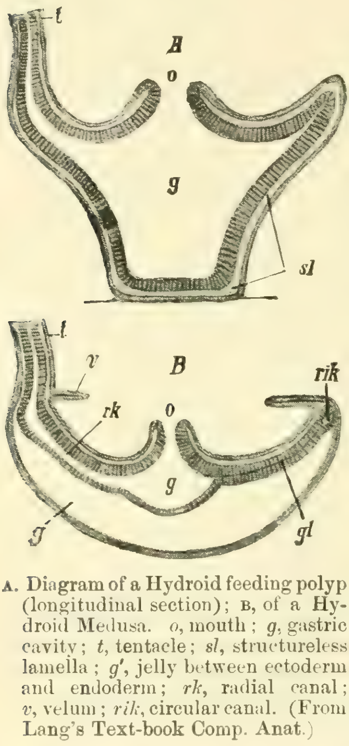
The fine specimen of *Pennaria caroliniana** from Naples shows a branching colony, the polyps of which possess a ring of filiform

Case 3.

tentacles at the base and scattered knobbed tentacles above. The two kinds of tentacles can be clearly seen in this specimen with the aid of a simple lens.

*Hydractinia echinata** (Figs. 8, 9) is always found forming a white fleecy covering on univalve shells inhabited by Hermit Crabs. "The waving forest of tall and graceful polypites generally reaches its greatest height towards the mouth (of the shell), round the edge of which are set the curious snake-like appendages. Intermingling with the perfect polypites are the rudimentary zooids, which carry the generative sacs, attenuated by their work and looking as if weighed down by their burden" (Hincks). The polyps rise from a chitinous crust covered with conical serrated spines.

FIG. 5.



A. Diagram of a Hydroid feeding polyp (longitudinal section); B, of a Hydroid Medusa. *o*, mouth; *g*, gastric cavity; *t*, tentacle; *sl*, structureless lamella; *g'*, jelly between ectoderm and endoderm; *rk*, radial canal; *v*, velum; *rik*, circular canal. (From Lang's Text-book Comp. Anat.)

*Monocaulus imperator** (Fig. 10), one of the most remarkable acquisitions of the *Challenger* Expedition, was obtained from depths of 1,875 and 2,900 fathoms in the North Pacific. A naked stem over seven feet in length, and bulbous at the lower end, is surmounted by a large polyp with basal and oral circles of filiform tentacles. The polyp was pale pink, and measured nine inches in breadth across the expanded basal circle of tentacles. The exhibited specimen (Case 3) is sadly altered from what it was in life; but, as Sir Wyville Thompson observed, "these delicate things, drawn up rapidly through the water from a depth of four statute miles, suffer greatly from this violent change."

The specimens almost seemed to melt away, and had to be promptly put into alcohol, which has hardened and contracted them to their present condition.

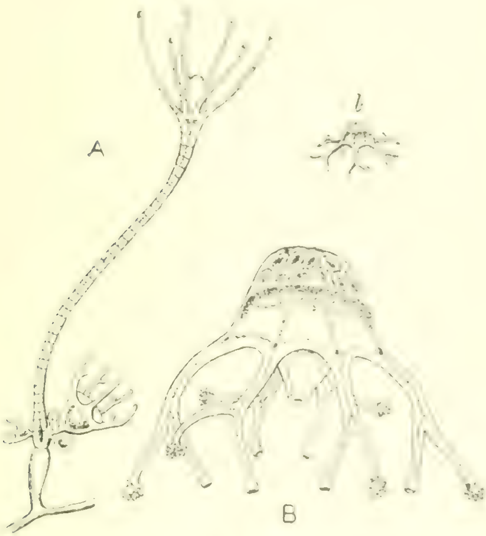
*Cordylophora lacustris** is a fresh-water Hydroid, with branches rising from a creeping stolon to a height of two or three inches;

the polyps are ovoid and provided with scattered filiform tentacles.

The dried specimens of *Ceratella* and *Chitina* in Case 3A are composed of a dense network of horny tubes. In life the surface of the branches is covered with large club-shaped polyps provided with scattered knobbed tentacles.

THECAPHORA (or *Calyptoblastea-Leptomedusae*). This group includes many of the more familiar forms of zoophytes (Case 3A, B).

FIG. 6.



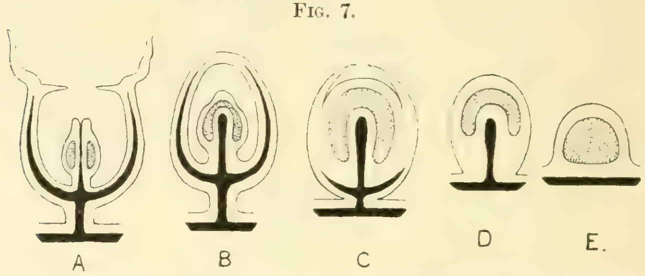
A. *Clavatella prolifera* (magnified); at base, clusters of generative polyps, one of which is nearly ready to become detached. B. Free-creeping generative polyp or Medusa, highly magnified; *b*, the same slightly enlarged. (After Hincks.)

The feeding polyps can be retracted into horny cups, and the generative polyps (which are budded off from a blastostyle, and which may be fixed or free-swimming) are enclosed in a horny capsule. The Medusae (Leptomedusae) develop the eggs in the radial canals. There are three sub-groups—the Campanularina, with stalked cups, the Sertularina, with sessile cups, and the Plumularina, in which occur little supplementary cups called nematophores, containing an offshoot from the common body substance of the colony loaded with thread-cells.

Case 3. *Obelia longissima** (*Obelia* sp., Fig. 11) forms very slender branching-stems; the cups are borne on ringed pedicels, and resemble wineglasses. The generative polyps, which are borne on a blastostyle, become free Medusæ.* The latter are tiny crystal bells with numerous tentacles and with eight litho-cysts; they often swim with the umbrella everted and the manubrium projecting from the centre of the convexity.

Case 3A. *Sertularia abietina*, the Sea Fir Zoophyte (Fig. 12, and specimen in Case 3A), forms clusters of brown pinnately-branched stems from six to twelve inches in height. It is often seen among heaps of seaweed on the shore, or attached to oyster and scallop shells in fishmongers' shops; the rather large horny cups, which are arranged alternately on

FIG. 7.



Diagrams illustrating the gradual degeneration of the Medusa bud into a mere rounded swelling. The black represents the stomach and its continuations; the lighter shading represents the reproductive cells. A. Attached Medusa; B. The same with margin of umbrella closed over manubrium; C, D, E, further stages. (After Lankester, Encyc. Britannica.)

each side of the branches, are swollen at the base and narrowed at the circular orifice. The oval reproductive capsules are slightly stalked.

Case 3A. *Sertularia argentea*,* or the Squirrel's Tail Zoophyte, *S. cupressina*, the Sea Cypress, and *Thuiaria thuja*, the Bottle Brush Coralline, are all expressively named by Ellis from their general appearance. In these species the sessile cups are arranged alternately on opposite sides of the branches. In *Hydrallmania falcata*, the Sickle Coralline, the cups are on one side only. In the five species above referred to the generative polyps (or degenerate Medusæ) are permanently attached to a degenerate feeding polyp or blastostyle, the whole being enclosed in a horny capsule.

Case 3B. *Antennularia antennina*, the "Lobster's Horn Coralline, or Sea Beard"* (Fig. 13, and specimen in Case 3B), forms long jointed

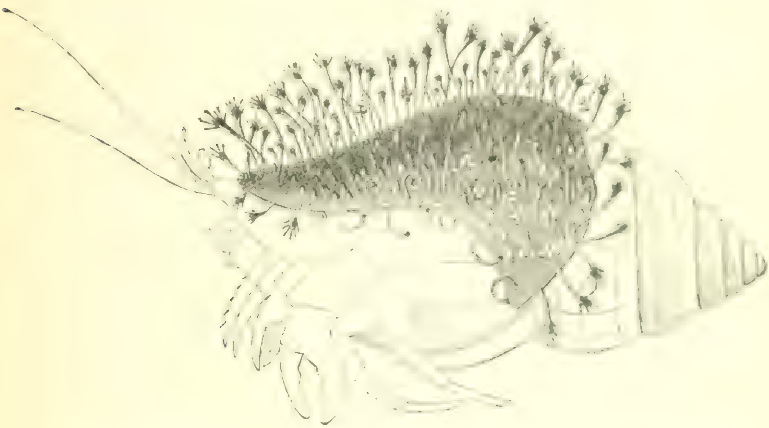
stems giving off whorls of slender branchlets bearing the minute cups and still more minute funnel-shaped nematophores.

A. ramosa (Case 3B) has branched stems.

In *Aglaophenia pluma*, the "Podded Coralline," the reproductive capsules are protected by a pod-shaped receptacle formed by modified branchlets which curve round and meet.

Aglaophenia urens,* from Java, is named on account of its severe stinging properties. Some species of this genus living in the Tropics attain a height of several feet, and it is dangerous to come in contact with them.

Fig. 8.

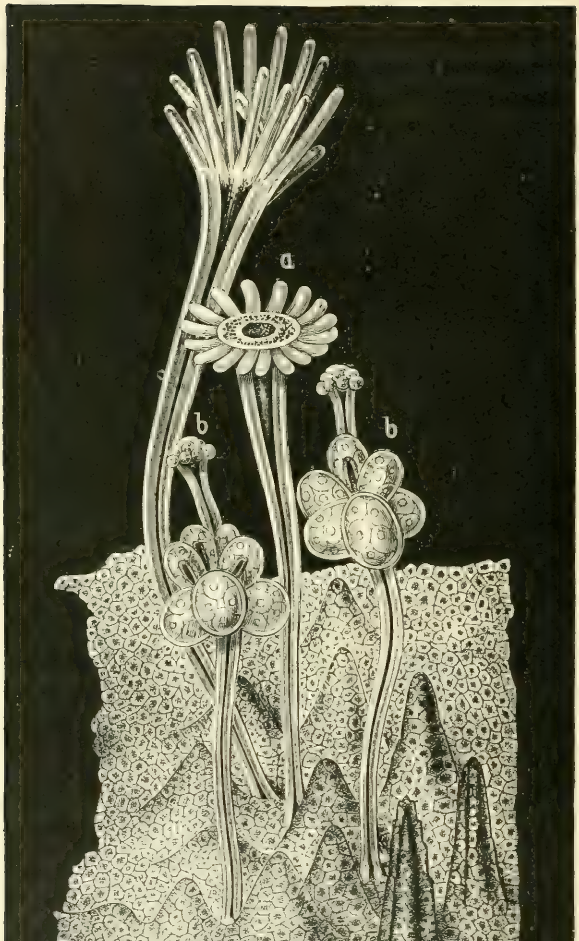


Hydractinia echinata on a shell of a whelk inhabited by a Hermit Crab. (Natural size.)

II. HYDROCORALLINÆ OR CORAL-LIKE HYDROZOA.

The Hydrozoa of this group resemble the Reef Corals in forming [illegible] a calcareous skeleton; indeed, the Hydrocoralline were supposed to belong to the same class (Anthozoa) as the Corals, till Agassiz showed that *Millepora* was a true Hydrozoon. Later, Moseley, in his classical work on the *Challenger* Hydrocorallinæ, confirmed Agassiz' results, and proved that the *Stylasterinæ* were also Hydrozoa. In all the Hydrocorallines two forms of polpys (Fig. 16) occur, viz., gastrozooids, with mouth and stomach, and tentacle-like dactylozooids without a mouth; the gastrozooids are contained in pits

Fig. 9.



Hydractinia echinata. *a*, feeding polyps; *b*, reproductive polyps (female). (Magnified.)

termed gastropores, and the dactylozooids in smaller pits termed dactylopores, the pores being usually arranged in systems (Figs. 18 and 19).

MILLEPORIDÆ. *Millepora* forms massive laminate or branched calcareous growths, and presents a great variety of forms; but, according to Prof. Hickson, there are no definite specific characters separating one form from another, and consequently we must regard the forty or more so-called species as mere variations of only one species, viz., *Millepora*

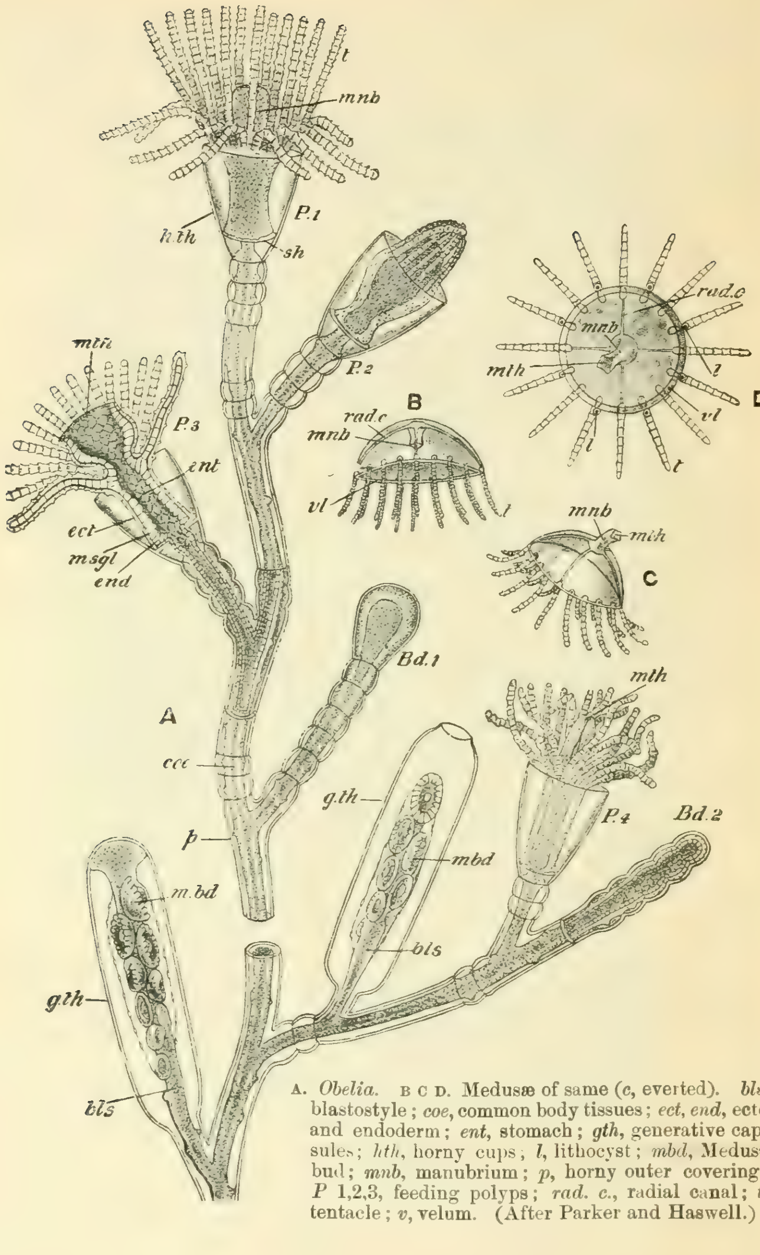
FIG. 19.

Monocaulus imperator. upper third. (Much reduced.)

alcicornis, or the Stag's Horn Millepora. He would call, for instance, *M. verrucosa* (Case 4, upright portion) *M. alcicornis*, facies *verrucosa*.

It seems that an embryo settling down on a broad surface with room to spread forms a laminate growth, such as the typical *M. alcicornis* or *M. complanata* (Case 4); but if it settles on a small object it tends to form a branching growth. *Millepora* often encrusts old bottles, &c.; in Case 3A a delicate network of Fan Coral is exhibited coated with a thin crust of *Millepora alcicornis*. Systems consisting of small gastropores, surrounded by irregular circles of about six still

FIG. 11.



A. *Obelia.* B C D. Medusæ of same (*c*, everted). *bls*, blastostyle; *coe*, common body tissues; *ect*, *end*, ecto and endoderm; *ent*, stomach; *gth*, generative capsules; *hth*, horny cups; *l*, lithocyst; *mbd*, Medusa bud; *mnb*, manubrium; *p*, horny outer covering; *P* 1,2,3, feeding polyps; *rad. c.*, radial canal; *t*, tentacle; *v*, velum. (After Parker and Haswell.)

Fig. 12

Sertularia abietina. A. Slightly enlarged. B. Branchlet magnified; *a*, polyps; *b*, reproductive capsule (original). The cellules on right side of Fig. B are closed by horny lids.

Case 4. smaller dactylopores, can be seen scattered over the surface of these corals. A section shows in the cavities of the calicles series of

FIG. 13.

Antennularia antennina. A. Natural size. B. Joint of stem with branchlets magnified; *a*, polyp; *b*, nematophore; *c*, reproductive capsule. C. Branchlet highly magnified (lettering as before). (After Allman.)

parallel floors (tabulae) marking successive stages of growth activity. *Millepora* is richly provided with thread-cells, which retain their

Fig. 14.

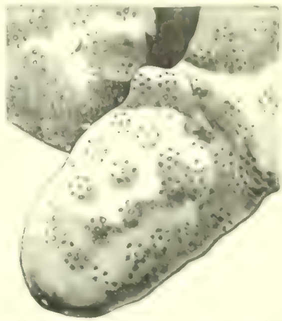
Stylaster flabelliformis. (One-half natural size.)

To face p. 53.

efficiency even on old dried specimens. The degenerate dactylozooids have a number of capitate tentacles, while the gastrozooids have only a whorl of four (Fig. 16).

In 1891 Prof. Hickson discovered the male, and in 1894 the female Medusa (Fig. 17) of *Millepora* in small capsules, which, when occurring near the surface, form rounded swellings (ampullæ). Latterly, Mr. Duerden has seen the living Medusæ in his aquarium at Jamaica. This tiny Medusa is only about $\frac{1}{50}$ inch in diameter; its cavity is nearly filled up by the large manubrium containing the eggs. The umbrella is devoid of canals, tentacles, and sense-organs, but is provided with batteries of thread-cells; and usually no mouth can be seen at the end of the manubrium. The little creature, however, is able to swim away with its heavy burden of eggs from the parent colony; having deposited the eggs, it shrivels up.

Fig. 18.[1]



Fragment of *Millepora*, showing the circles of dactylopores each with a central gastropore. (Twice natural size.) (After Moseley.)

STYLASTERIDÆ. In this family the dactylozooids are without tentacles, and one or both kinds of zooids are supported in their calicles by a calcareous style. There are several genera in this family.

In *Stylaster* the pores are arranged in "cyclo-systems"—a circle of dactylopores surrounding a central gastropore. A cyclo-system presents a deceptive resemblance to the calicle of an ordinary coral: in the latter the calicle contains one coral polyp, but in the cyclo-system there are a dozen or more degenerate individuals surrounding a central individual; the dactylozooids were formerly supposed to be the tentacles of the central zooid. The generative buds, which are situated in the often numerous swellings or ampullæ, never become free Medusæ.

The Stylasters are remarkable for the elegance and beauty of their arborescent fan-shaped forms (Fig. 14) and their exquisite colouring. Several specimens of *Stylaster roseus* from off a cable from the West Indies show considerable variation in colour, being white, rose-pink, and salmon-coloured. The cyclo-systems regularly alternate on the sides of the slender branches.

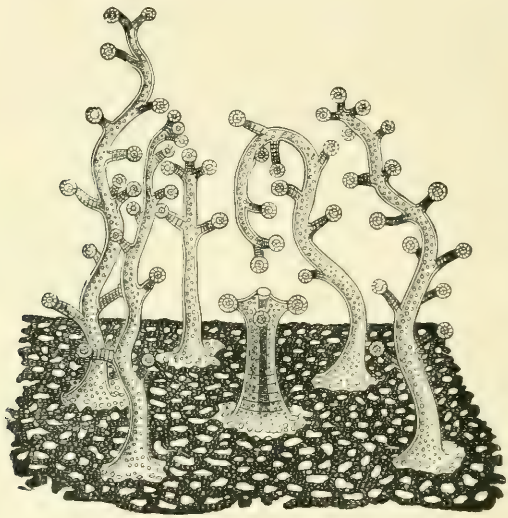
[1] From "Encyclopædia Britannica."

Case 2 c, d. *Stylaster sanguineus*, or the "Blood Coral" from the Pacific Islands, is of a brilliant red colour.

In *Astylus* (Fig. 18) the cyclo-systems all face one way. *Cryptohelia pudica* is remarkable for the little canopy which arches over each cyclo-system.

Distichopora has the pores arranged in a triple row along each edge of the flattened branches, a central row of gastropores being enclosed between two parallel rows of dactylopores. Probably the various supposed species of *Distichopora* (*D. coccinea*, *violacea*, *livida*) are colour variations of one species.

Fig. 16.[1]



Enlarged view of the surface of a living *Millepora*, showing five dactylopore polyps surrounding a central gastropore polyp. (After Moseley.)

III. MEDUSÆ AND OTHER ALLIED FREE-SWIMMING CŒLENTERA.

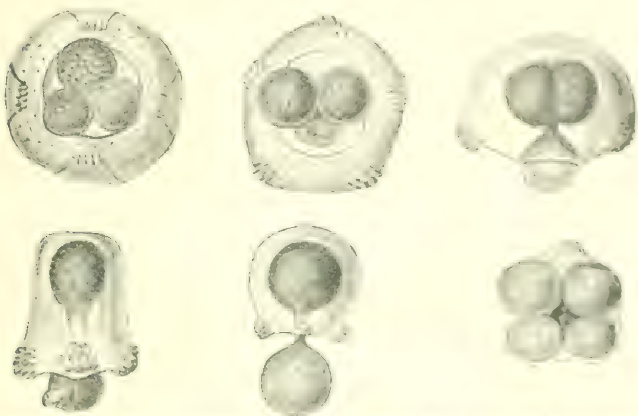
Case 3, Upright part. Glass models of Medusæ or Sea-Nettles are exhibited in the upright part of Case 3 along with specimens in spirit. Medusæ have already been referred to in the account of Hydroida and of *Millepora*, where it was stated that in some species certain polyps carrying the eggs (generative polyps) became detached

[1] From "Encyclopædia Britannica."

from the parent colony and swam away. In the case of deep-sea Medusæ, the eggs develop directly into Medusæ, no fixed stage being known; here the fixed stage, which there is reason to believe has at one time existed in every case, has been "hurried through" in the egg. Medusæ present two very different types of structure: in one, which may be called the "Hydromedusan" type, the umbrella is provided with a velum, the sense-organs are naked on the umbrella margin (Naked-Eyed Medusæ), and the fixed stock, when known, is of the *Hydra* or Hydroid type, and produces buds laterally. Medusæ of this type come under the sub-class *Hydromedusæ*, which includes *Hydroida* and *Hydrocorallinæ*.

In Medusæ of the second or "Scyphomedusan" type the

Fig. 17.[1]



Female Medusa of Millepora, showing the eggs and marginal batteries of thread cells. (After Prof. S. J. Hickson.)

umbrella is without a velum, the marginal sense-organs are covered by little lappets (Covered-Eyed Medusæ), rows of "gastral filaments" project into the stomach cavity, and the fixed stock, only known in a few cases, is a broad flattened polyp (Scyphistoma[2]), which produces buds by transverse fission (Fig. 19), and has four longitudinal ridges along the walls of the stomach cavity. Scyphomedusan Medusæ are included in the sub-class *Scyphomedusæ*.

Hydromedusan Medusæ. The tiny Medusæ given off from the fixed stocks of Hydroid Zoophytes come under two groups. Those

[1] From "Proceedings of the Royal Society."
[2] *Skyphos*, a cup; *stoma*, mouth.

Case 3, Upright part. detached from the flower-like stocks of Athecate Hydroids come under the *Anthomedusæ;* they have naked eye-spots (Fig. 4), and the eggs are formed in the walls of the manubrium; see *Rathkea fasciculata*,* a little Medusa which is given off from a small solitary fixed polyp with four tentacles. The early history of *Pandæa conica** and *Tiara pileata*,* both of which are *Anthomedusæ*, is unknown.

The Medusæ of the Thecate Hydroids come under the *Leptomedusæ* (see *Obelia*,* Case 3, and Model of *Rhegmatodes thalassina*); the eggs are formed in the radial canals, and the sense-organs are either eye-spots or "litho-cysts," the latter being vesicles containing a hard concretion which transmits impressions from the outside to delicate "auditory" cells. In certain *Hydromedusæ* the sense-organs arise on modified tentacles known as tentaculo-cysts. These forms, which come under Haeckel's Orders *Trachomedusæ* and *Narcomedusæ*, have no known "Hydroid history," and in some cases are known to develop direct from the egg; see *Carmarina hastata* (Fig. 20), and Model in Case 3A. Two fresh-water Medusæ are known, both of which are *Hydromedusæ Limnocodium sowerbii*, from the Victoria Regia Tank in the Royal Botanical Society's Gardens, has a shallow umbrella less than half an inch in diameter and with numerous tentacles; the fixed phase occurs as a columnar polyp about a quarter of an inch in height, simple or branched once or twice; medusa buds arise from the summit; the original habitat was probably the Amazon region. The second species, *Limnocnida tanganyicæ*, comes from Lake Tanganyika; the umbrella is about an inch across, the manubrium is very wide and shallow, and the stomach-cavity is nearly filled up by the convex lens-like central area of the under surface of the umbrella.

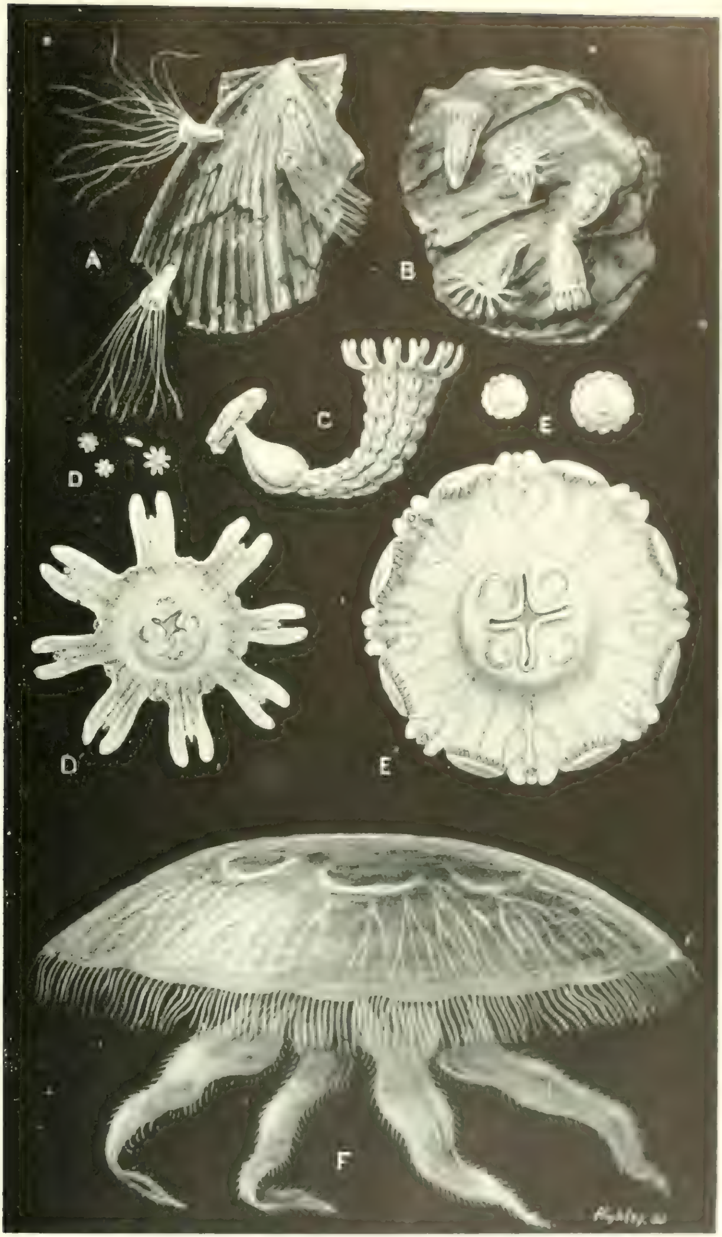
Fig. 18.[1]

Portion of *Astylus* showing cyclosystems each with a central gastropore and zone of slite-like dactylopores. (After Moseley.)

Case 3, Upright part. Finally the Medusæ of *Millepora* and the swimming-bells, &c., of the Siphonophora belong to the Hydromedusan type.

SCYPHOMEDUSAN MEDUSÆ (*Scyphomedusæ*). These include the

FIG. 19.



Life history of *Aurelia.* A, "*Hydra tuba*" [illegible] (Scyphistoma) [illegible]. B, The same undergoing transverse division (enlarged) [illegible]. Ephyrae (natural size and enlarged). E, E. Young *Aurelia* (natural size and enlarged). F, Fully-grown *Aurelia.*

larger and commoner kinds of Jelly-Fish or Sea-Nettles. A brief account is given below of *Aurelia aurita** (Model and specimens in Case 3), whose phantom disks are so often seen in autumn time slowly swimming below the surface. In the centre of the shallow umbrella are four purple horseshoe-shaped or circular generative masses; in the centre of the under surface is the manubrium prolonged into four arms; the margin of the umbrella is provided with a fringe of very short fine tentacles, the uniformity

Fig. 20.

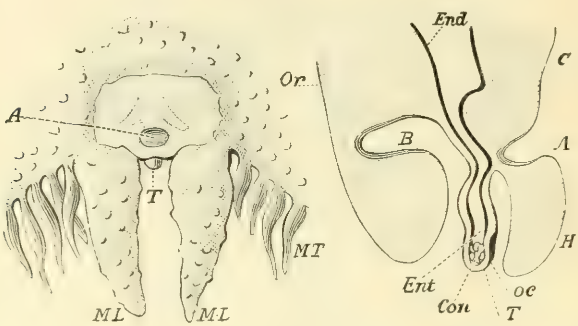
Carmarina hastata, one of the *Trachomedusæ*. (After Haeckel, and from Ency. Britannica.)

of the fringe being broken by eight notches, each containing a tentaculo-cyst; each of the latter (Fig. 21) is covered by a pair of minute lappets, hence Medusæ of this type were called Covered-Eyed; while those of the Hydromedusan type, being without lappets, were called Naked-Eyed.

The thickness of the umbrella is traversed by a system of simple and branched canals, which pass from the central stomach to a circular canal running round the margin of the umbrella. Fi

Case 3, Upright part. jecting from the stomach walls are four groups of gastral filaments loaded with thread-cells. The purple reproductive masses project from the floor of the stomach cavity; at the base of the manubrium outside are four pockets, which bring the water very near to these masses. *Aurelia* has no velum in the adult state. The fertilised egg develops into a hollow oval ciliated embryo, which settles down and becomes a small polyp with mouth and stomach and sixteen tentacles; this phase was formerly supposed to be a distinct individual, which was named *Hydra tuba*, or the Trumpet Polypus. A very fine example sent by the Plymouth Biological Station is exhibited in Case 3 (Fig. 19A), numerous specimens of the little

Fig. 21.



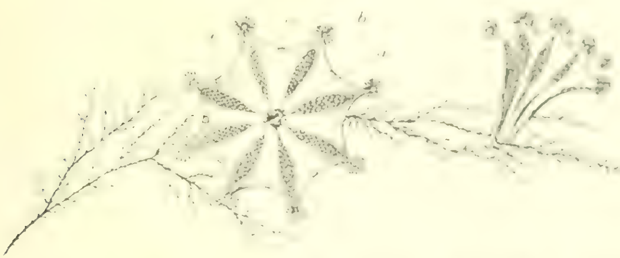
Tentaculocyst and marginal lappets of *Aurelia aurita*. In the left-hand figure —*ml*, marginal lappets; *t*, tentaculocyst; *a*, superior olfactory pit; *mt*, marginal tentacles of the disc, magnified about 50 diameters. In the right-hand figure—*a*, superior olfactory pit; *b*, inferior olfactory pit; *h*, hood or bridge joining the marginal lappets; *t*, tentaculocyst; *con*, auditory concretion; *oc*, ocellus. (After Eimer, from Encyc. Britannica.)

polyp being attached to a shell; this fixed phase of *Aurelia* is now called the "Scyphistoma" stage, on account of the shallow cup-like oral region, contrasting in this respect with the elongated narrow conical oral region of Hydra and Hydroid polyps. In course of time the little Scyphistoma undergoes "transverse fission," and resembles a pile of saucers with crenulated rims (Fig. 19B). Presently the saucers detach themselves (specimens, Case 3) and swim away; they are now known as *Ephyra* Medusæ, or the *Ephyra* stage (Fig. 19C; specimens, Case 3); the last stage in this wonderful transformation consists in the filling in of the spaces between the eight bifid arms of the Ephyra and the development of

a fringe of fine tentacles on those intervening portions, the ends of the bifid arms now occupying the notches in the rim and forming the lappets of the sense-organs; the medusa is now recognisable as *Aurelia*.

The fixed Scyphistoma stage is not common, many Scyphomedusae developing direct from the egg. The Scyphomedusae are divided into four Orders. The first Order includes the exceptional *Lucernaria-Haliclystus* (*Lucernaria octoradiata*)* (Fig. 22) is shaped like a vase with a short stem. The upper edge is produced into eight arms each crowned with a tuft of tentacles. The animal, which fixes itself by its stalk, can creep along or swim. On the margin, between the tufts of tentacles, are peculiar modified tentacles known as anchoring bodies, which assist progression by sticking to and grasping the surface of the sea-weeds or stones. The mouth

FIG. 22.



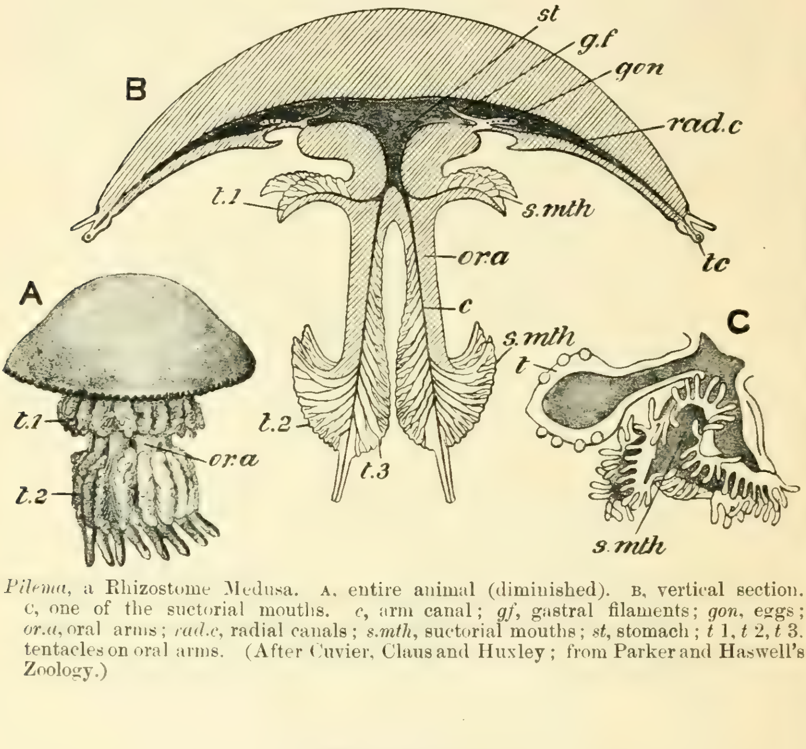
Haliclystus octoradiatus, a Lucernarian Medusa, on sea-weed. *a*, mouth and stomach; *b*, tentacles; *c*, anchors; *d*, reproductive glands. (From Johnston's British Zoophytes; figures slightly altered.

and stomach (manubrium) are in the centre. *Haliclystus*, which is commonly found adhering to sea-weeds, varies in colour, being olive-brown, green, or pink. The second Order (Discomedusae) includes the commoner kinds of Jelly-Fish, *Pelagia*, *Aurelia*, *Pilema*, *Cotylorhiza*, &c. (see Case 3). In *Pilema* (Fig. 23) and other "Rhizostomatous" forms the lips and arms of the manubrium are fused together, and the food, consisting of minute marine organisms, is taken in through little suctorial mouths and conveyed up long canals. *Pilema octopus** is fairly common. Specimens often attain a diameter of two feet. The greenish umbrella has a purple frill-like margin; there are eight tentaculo-cysts with their special lappets, but there are no tentacles round the margin of the umbrella. The large mouthless manubrium breaks up into eight long arms often attaining a length of two feet; the minute

Case 3, Upright part. almost microscopic suctorial mouths armed with fine tentacles (Fig. 24c) are abundant in the cauliflower-like regions of the arms.

Very commonly small fish are found associated with the larger Medusæ, which doubtless shelter their protégés and enable them to dodge out of the way of their enemies. The majority of known Medusæ do not live at any great depth, but a few forms inhabit the deeper zones of the ocean.

Fig. 23.



Pilema, a Rhizostome Medusa. A, entire animal (diminished). B, vertical section. C, one of the suctorial mouths. *c*, arm canal; *gf*, gastral filaments; *gon*, eggs; *or.a*, oral arms; *rad.c*, radial canals; *s.mth*, suctorial mouths; *st*, stomach; *t* 1, *t* 2, *t* 3. tentacles on oral arms. (After Cuvier, Claus and Huxley; from Parker and Haswell's Zoology.)

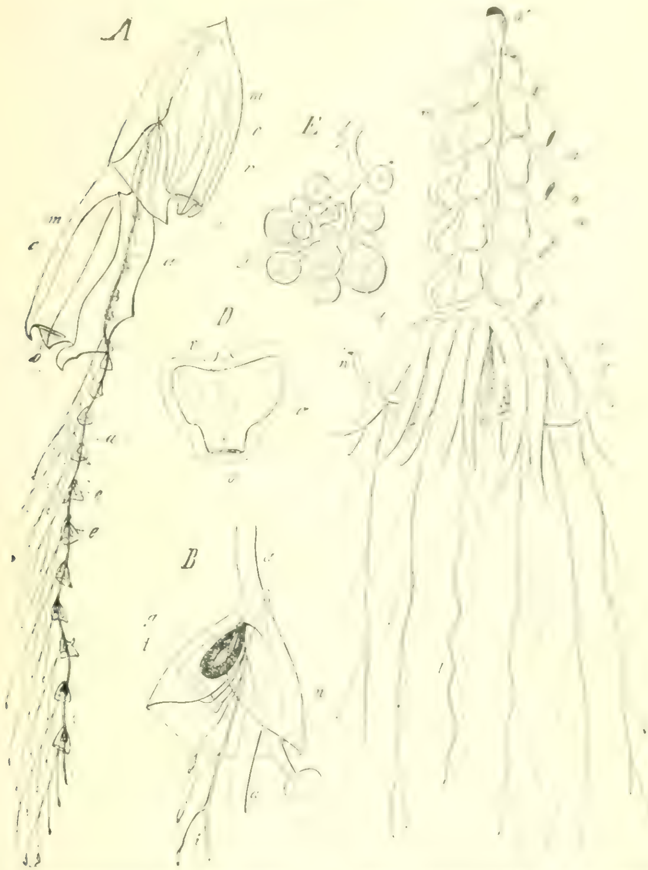
Siphonophora.

The members of this group are free-swimming colonial Hydrozoa, in which the individuals composing the colony are modified in various ways according to the work they perform.

Case 3. Upright part. In *Physophora* (Fig. 24c), for example (see Models and specimen in Case 3), a hollow stem or siphon is provided at its upper end with a small air-sac, below which follows series of swimming-

bells, medusa-like individuals, each consisting simply of an umbrella, [illegible] and adapted solely for swimming; next follows a whorl of leaf-like [illegible]

FIG. 24.



Floating colonies of *Siphonophora*. A. *Diphyes campanulata*. B. A group of appendages from the stem of *Diphyes*. C (Fig. on right). *Physophora hydrostatica*. D. Swimming-bell of the same. E. Cluster of generative buds (degenerate medusae) of *Agalma*. a, stem of colony; a', air sac; m, swimming-bell; c, concavity of same; r, pallial canals; o, orifice of umbrella; t, covering pieces in B, tentacle-like polyps in C; n, stomach; i, tentacles; g, generative buds. (After Gegenbaur, from Encyc. Britannica.)

"covering-pieces," and below this a cluster of medusa-like [illegible] polyps, tentacle-like polyps and short-stalked feeding polyps, each [illegible]

Case 3, Upright part. the last having attached to its stalk a long tentacle armed with thread-cells.

In *Physalia*, the "Portuguese Man-of-War" (Fig. 25), the air-

Fig. 25.

Physalia floating on the surface; *cr*, crest; *p*, a polyp; *pn*, air sac. (After Huxley; from Parker and Haswell's Zoology.)

sac takes the form of a large pear-shaped bladder provided with a many-chambered crest; a mass of generative buds and feeding polyps with long tentacles is suspended from the under surface of the

float; there are no swimming-bells or covering-pieces. *Physalia pelagica* (Model, Case 3) has one long stout main tentacle and numerous lesser ones; *Caravella* * (Model, Case 3) has numerous large tentacles. The float is borne wholly above the surface, and is carried along by the breeze with the broad end foremost and the tentacles trailing behind. Prof. Agassiz saw specimens with tentacles over fifty feet in length. Physalia is notorious for its dangerous stinging properties.[1]

Rhodalia miranda * is a deep-sea Siphonophore, wonderfully adapted for living at great depths; the depressed oval air-sac is followed by several circles of swimming-bells each attached by a broad vertical lamella to the stem.

A curiously modified swimming-bell, the aurophore, allows of communication between the air-sac and the water; by emptying or secreting the air or gas the animal can sink or rise within certain limits without using its swimming-bells. The "stem" is not a delicate tubular siphon as in *Physophora*, but forms a thick mass permeated by canals, the feeding polyps with tentacles and generative buds being attached to its lower surface.

Most of the swimming-bells and all the tentacles have become detached in the specimen, the red colour of which is artificial; but the air-sac and massive stem are well preserved. The specimens were obtained by the *Challenger* from a depth of 600 fathoms in the South Atlantic.

Diphyes * (Fig. 24 A, B), which is without an air-sac, has two swimming-bells, and below these groups of covering-pieces, feeding polyps, and generative buds situated along the stem.

In *Velella*,* or "By-the-wind Sailer" (Case 3), a vertical semicircular "sail" is attached diagonally across the upper surface of an oblong disk; attached to the lower surface of the latter are one large central feeding polyp and circles of smaller feeding polyps, generative buds, and a marginal fringe of tentacles. Fleets of *Velella* sailing along in the breeze are more commonly seen in warm latitudes, but specimens, both of *Velella* and *Physalia*, have been found off the south-west coasts of England.

Porpita * consists only of a circular disk with its dependent polyps and tentacles.

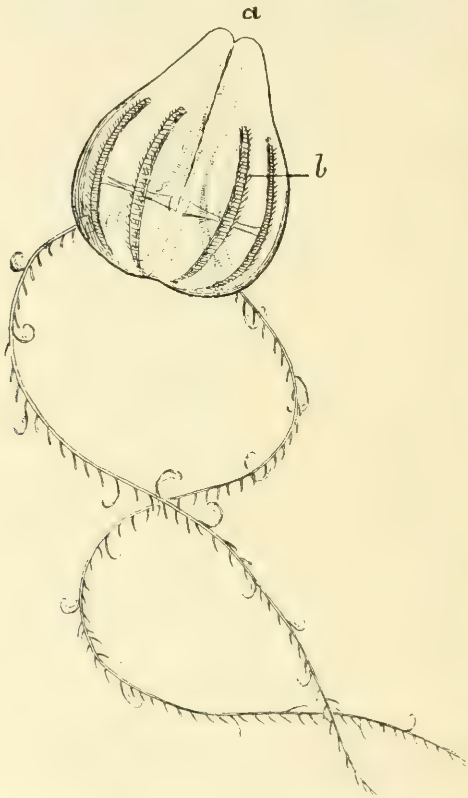
[1] Mrs. David mentions in her book on Funafuti that the natives are more afraid of *Physalia* than they are of the sharks.

Ctenophora (Comb-Jellies).

Case 3, Upright part.

Ctenophora are free-swimming Cœlentera which never form colonies. The body, usually oval or spheroidal, is provided with eight rows of swimming-plates situated along eight meridians, each

Fig. 26.



Hormiphora plumosa. *a*, mouth ; *b*, swimming plates. (After Chun.)

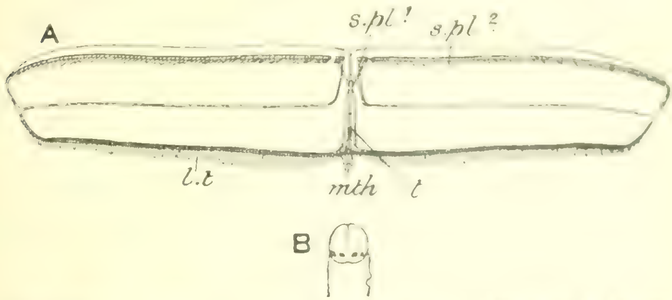
plate consisting of a comb-like band of very large cilia. The mouth, situated at the oral pole, leads into a gullet and stomach, whence canals proceed to run beneath the swimming-plates ; canals also pass upwards from the stomach to the aboral pole, where they open

to the exterior on each side of a centrally-placed "auditory" or balancing sense-organ.

Some Ctenophorans are provided with a pair of plumose tentacles, which can be retracted into receptacles. *Hormiphora plumosa** (Fig. 26) has a small pear-shaped body, the mouth being at the narrow end: the eight rows of swimming-plates occupy about two-thirds of the length of the body; a pair of long feathery tentacles can be emitted from two tentacle-sheaths, which open one on each side of the body not far from the aboral pole.

Cestus veneris, or "Venus' Girdle"* (Fig. 27), has a long band-shaped body, which may attain a length of several feet; the mouth is in the centre of the lower border, and the gullet and stomach occupy quite a narrow area in the centre of the band; the eight

FIG. 27.



Cestus veneris. A. adult. B. young. *mth.* mouth; *t*, tentacles; *l.t*, lateral tentacles; *spl*¹, one of the four short rows of swimming plates; *spl*², one of the four long rows of swimming plates. (After Chun; from Parker and Haswell's Zoology.)

rows of swimming-plates form an apparently continuous line at the edge of the upper border. The young *Cestus* is spheroidal, but soon becomes compressed in a vertical plane and lengthened out.

Cestus swims mainly by the wavy and serpentine motion of its body. The small exhibited specimen shows the aboral border, with its apparently continuous rows of swimming-plates nearest the front of the glass.

*Beroe ovata** from Naples is in the form of a large sac with a wide mouth; the cavity of the sac is, strictly speaking, the gullet, the stomach occupying only a small space at the base.

Beroe ovata can alter its shape to a remarkable extent when swimming, being now V-shaped with widely-gaping lips, now U-shaped: the creature is extremely voracious and swallows into

Case 3, Upright part.

capacious gullet animals that at first sight appear bigger than itself.

The Ctenophora are now usually regarded as a distinct class of Cœlentera.

Classification of Hydrozoa.

(From Prof. Lankester's Article Hydrozoa, *Encyclopædia Britannica.*)

Class Hydrozoa.

Sub-class Hydromedusæ | Sub-class Scyphomedusæ

Orders Gymnoblastea or Athecata. | Calyptoblastea or Thecaphora. | Trachomedusæ. | Narcomedusæ. | Hydrocorallinæ. | Siphonophora.

[The Cœlentera have been divided, in the various recent classifications, into two classes, Hydrozoa and Anthozoa; into three, Hydrozoa, Anthozoa, and Ctenophora; or, again, into four, Hydrozoa, Scyphozoa, Anthozoa, and Ctenophora.]

ANTHOZOA.

The existing Anthozoa are [illegible] they either have eight tentacles and [illegible] Sea-Anemone, they have a number of [illegible] only eight tentacles, as in the noble red coral, each is fringed at its sides, or, in technical terms, is pinnate; when the tentacles are numerous they are non-pinnate. A certain number of palaeozoic corals had a symmetry of four. We may therefore speak of Tetracoralla,[1] Hexacoralla,[2] and Octocoralla.[3]

Both of the latter may have (i.) soft bodies without spicules, (ii.) horny axes (horny corals), (iii.) a continuous limestone skeleton (stony corals); the Alcyonaria may have scattered spicules.

The Hexacoralla, or Zoantharia, commence at the eastern end of the Gallery, next the Hydrozoa; the Octocoralla, or Alcyonaria, commence at the western end of the Gallery.

The organisation of the Alcyonaria is illustrated by large diagrams; the first, that of *[illegible]*, is [illegible] a larval stage of some Alcyonarian; but it shows some of the essential characters of the group. These are a sac-like body, with an axial gastric cavity, giving off eight compartments, on the partition walls of which are developed the gonads or reproductive elements.

The organism seldom remains single; developing a stolon or creeping process, it gives rise to bud after bud, and so forms a colony, as in *Clavularia* (Figs. 1 and 2) [illegible] diagrams of which are shown. There are also some excellent water-colour sketches of Clavularians taken from life, and presented by Prof. Hickson, F.R.S.

The creeping process or stolon is well seen in the small preparation of the organ-pipe coral (*Tubipora*); as shown in Fig. 4, this is seen to be a small flat plate, [illegible] to rise up.

1 [illegible] 2 [illegible] 3 [illegible]

The tissues seldom remain soft; they become impregnated with horny matter or with carbonate of lime, or both. The horny skeleton is continuous; the calcareous consists of separate spicules more or less closely packed.

The differences at different ages in the amount of lime deposited are well shown by the fine series of specimens of *Isis* (Case 14). Colonies formed by budding and provided with a skeleton may become of great length, as *Juncella*, or of great intricacy of interlacement, as *Gorgonella*; the fine *Gorgonella verriculata* from Zanzibar should be noticed; often they are of exquisite beauty, as the *Calligorgia* from Mauritius (Fig. 5) or the *Hookerella* from South Japan suffice to show. Sometimes there is a continuous skeleton, as in the noble red coral of the Mediterranean, good specimens of which, showing the coral polyps expanded, and explanatory diagrams of which are exhibited in Case 13.

A particularly dense skeleton is developed in *Heliopora* (Fig. 6), the only living member of a group (Coenothecalia) which formed a large part of the coral fauna of Palaeozoic times. Long considered to be a Zoantharian, the affinities of *Heliopora* to the Alcyonaria were demonstrated by the late H. N. Moseley during the voyage of H.M.S. *Challenger*. This skeleton is remarkable for being always of a blue colour when collected on a reef; but, as Mr. Stanley Gardiner's collections show, the blue colour gets progressively paler as specimens are obtained from deeper and deeper water.

In other *Alcyonaria* a reduction of the skeleton seems to have occurred, so that the axis is friable and breaks up into scattered spicules; this is the case with *Paragorgia arborea*, a fine example of which from the coast of Norway is shown with an illustrative drawing as it appears during life, and a well preserved piece with the polyps partly extended.

In the *Pennatulidae* reduction goes still farther, and little is left in the way of a skeleton save a horny axis, which extends along the whole of the colony; a striking example is to be seen in the specimen of *Osteocella* on the south wall of the Gallery.

Fine examples of *Pennatula*, *Funiculina*, and others are shown, as well as two beautiful plates of *Umbellula encrinus*, taken from the Report of the Norwegian North Sea Expedition. The curiously modified and kidney-shaped *Renilla* should be noticed.

The general plan of the structure of the Octocoralla is shown by Mr. Berjeau's water-colour drawing in the Gallery, which is shown, reduced to a third, in the accompanying figure (Fig. 7), where we

remark the numerous non-pinnate tentacles (*t*), the cavities of which communicate with the general cavity (*c*), which is divided into compartments by septa (*m*), on the walls of which the [illegible] are developed. The axis is occupied by the stomach (*s*), which communicates below with the general cavity, and opens above by a mouth marked by a special slit (*sl*); *p* marks the point at which a chamber is in communication with its neighbour, and *d* is the lower surface of the disk. The specimens and explanatory labels in Case XIII. may be found of assistance in understanding the structure of corals.

As it is impossible to preserve in alcohol the beauty of form and colouring presented by Sea-Anemones, the aid of the artist has been called in, and sketches from life are shown on the walls.

As in the Zoantharia, there may be no spicules, a horny skeleton, or a continuous calcareous skeleton; but spicules scattered in the flesh are not known.

Of the soft-bodied forms other than the well-known Sea-Anemone of the shore, attention should be directed to the remarkable *Cerianthus membranaceus* (Fig. 8), which makes for itself a curious woven tube, open at either end. The effect of this is that, during a dredging operation, the *Cerianthus* generally succeeds in making its escape, and a mere empty tube is all that rewards the dredger.

The Antipatharia have a purely horny skeleton, which encloses a central canal and is always spiny. This skeleton may be a single rod, as in *Cirripathes*, where it may attain a great height, or consist of a collection of straight rods, as in the remarkable forms from Mauritius, which has been called *Antipathes robillardi*; or it may be more or less branched and form tufts or wide plates, as in *Aphanipathes*, or the branches may fuse with one another, as in *Arachnopathes*, an elegant example of which will be found by itself on the wall near the middle doors. The most common form is the tree-like *A. abies* (Fig. 9).

According to the recent researches of Dr. Carlgren, the large black coral-like structure which forms such a conspicuous object opposite the eastern door to this Gallery, and which is known as *Gerardia savalia* (Fig. 10), has been wrongly regarded as an Antipatharian or horny coral. It is, according to the Swedish naturalist, allied by the structure of its polyps to *Parazoanthus*, and must therefore be placed with the otherwise soft-bodied *Zoantharia*. The specimen here exhibited, with a suitable explanatory label, is surprisingly large, and nothing like it is possessed by any other Museum of Natural History.

The majority of the specimens belong to the group of stony corals or Madreporaria. The stoniness is due to the secretion of carbonate of lime by the skin of the lower part of the polyp. As the body grows against this unyielding surface it has to give way, and forms folds ; the skin of these folds again forms plates of carbonate of lime ; and thus we get the outer "wall" and the inner septa. The extent and proportion to which these are developed vary greatly, especially in the colonial forms. In these the nutrition of the colony is effected by a system of canals ; the appended figure (Fig. 11) is Dr. G. H. Fowler's representation of the canal system of *Rhodopsammia*. When, as in the genus *Madrepora* and its allies, this system perforates the substance of the coral (Fig. 12) the coral is said to be PERFORATE.

The result of budding, long continued and extending layer over layer, is the formation of large solid masses, which go to form coral reefs ; the final fate of reef-corals is well indicated in Case 6 B, where the specimens selected for the Museum by the late Mr. Darwin are shown. The size to which colonial masses of coral may grow may be judged from the two enormous specimens of *Turbinaria peltata*, which cover an area 16 feet and 16 feet 8 inches round, and weigh 12 cwt. and 13⅝ cwt.[1] respectively (Fig. 13). Sometimes a coral is by the force of the waves carried away from its resting-place ; if it be dead, and its substance filled with air, it may float ; if so, it will become, like the large mass of *Favia* (Fig. 14) shown at the entrance to the Shell Gallery, the sport of the waves, and may at last find its home on an island, where the species to which it belongs is never found in the living state.

Naturalists experience great difficulty in determining pieces of coral ; the reason for this is to be seen in the photographs of *Turbinaria*, where marked differences in appearance (Figs. 15, 16) are easily apparent. The causes of these differences are seldom easy to discover, and the guesses of stay-at-home naturalists are of little service. It seems certain that muddiness of water may be an important influence, as a deposit of sediment would kill the centre of a cup-shaped coral ; here and there indeed there are indications of spouts by which water may run off. The extraordinary differences seen in the large mass of "Brain coral," *Maeandrina cerebriformis* (Fig. 17), which is placed in the adjoining corridor, are due, it is suggested by one experienced in coral reefs, to a marked difference in the amount of sunlight which could reach the two halves of the mass.

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[1] 1 cwt. = 112 lbs. ; 60 kilograms is about equal to 1 cwt.

Fig. 1.

[illegible]

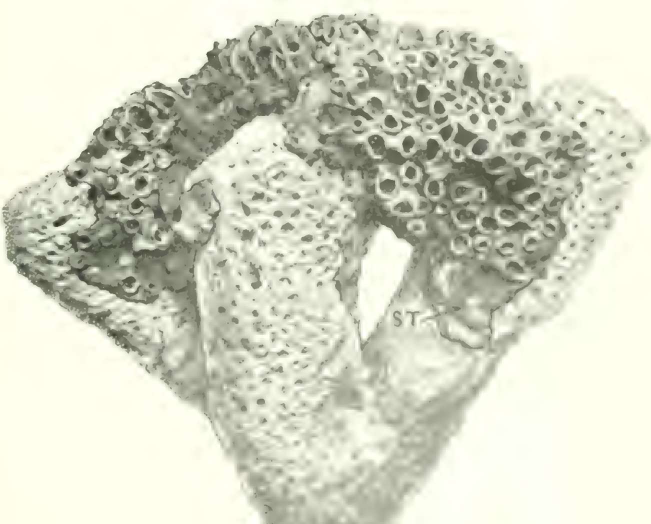
Fig. 2.

[illegible]

FIG. 3

ALCYONIUM

FIG. 4



[illegible]

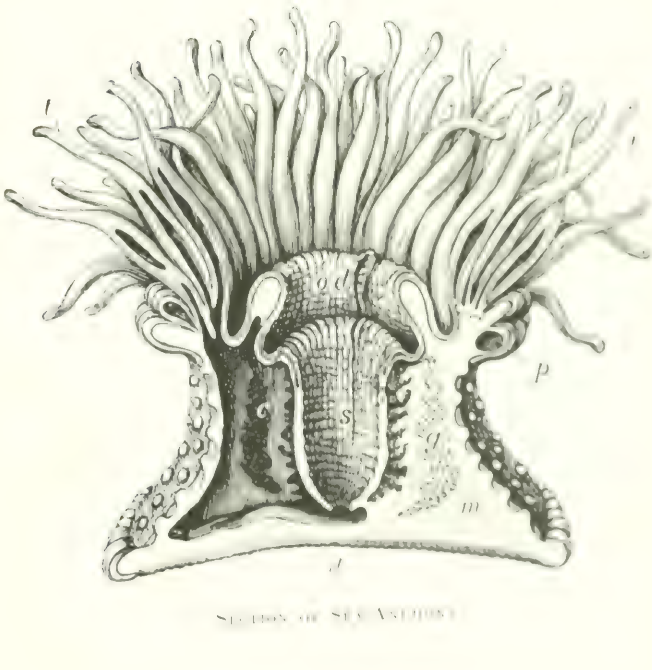
Fig. 5.

[illegible]

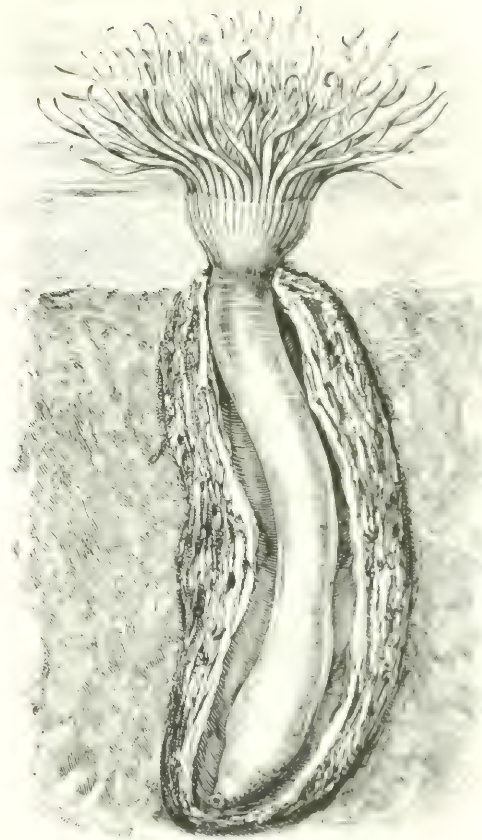
FIG. 6

HETEROPORA

FIG. 7



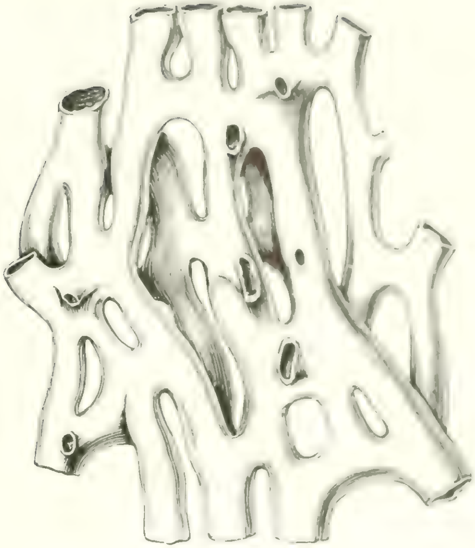
SECTION OF SEA ANEMONE



CERIANTHUS MEMBRANACEUS.

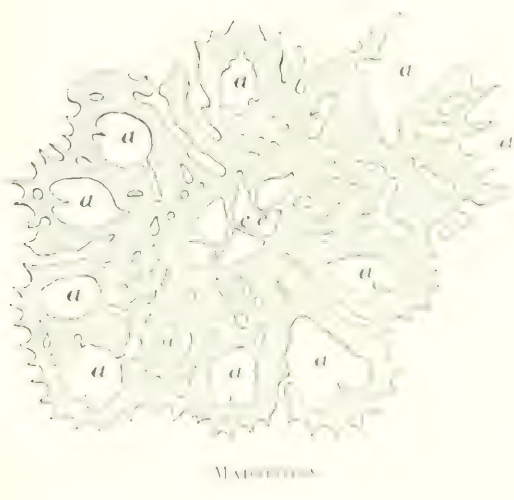
Fig. 10

Fig. 11.



Rhodopsammia.

Fig. 12.



Madrepora.

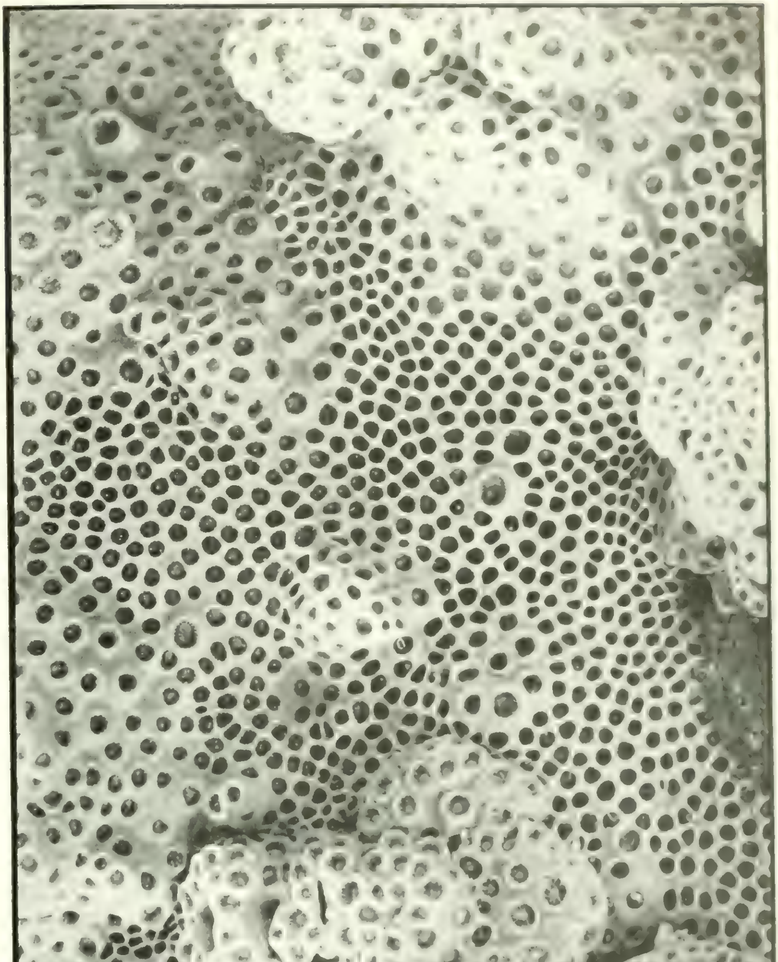
FIG. 13

[illegible]

[illegible]

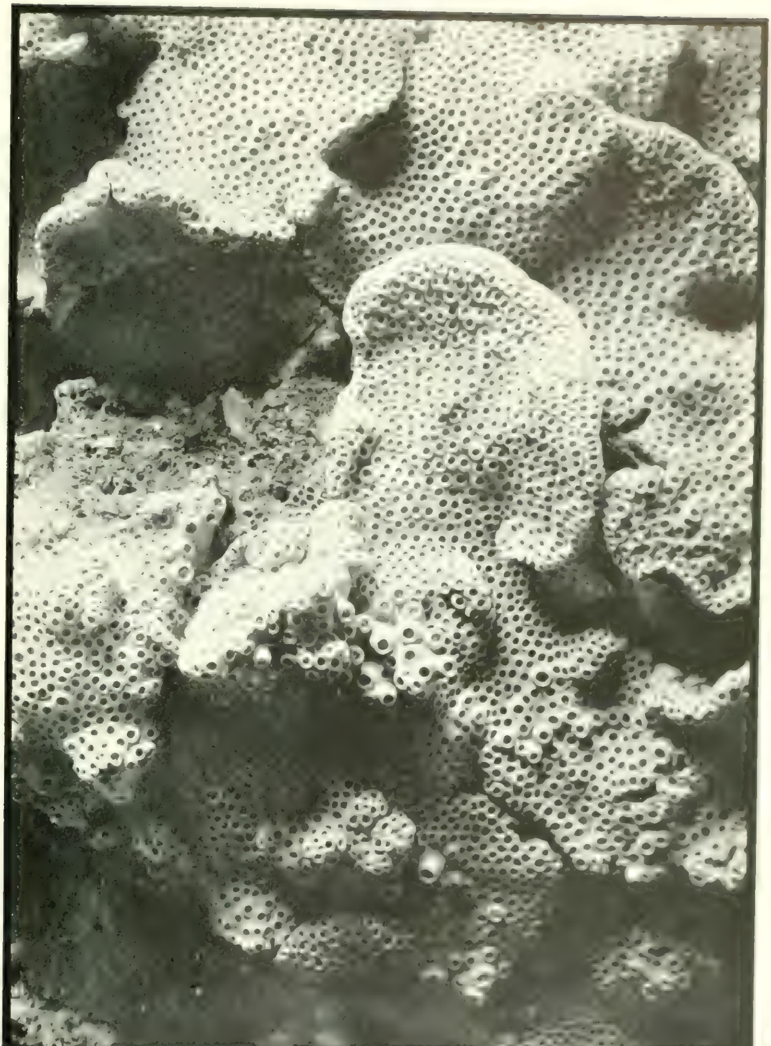
Favia.

FIG. [illegible]



TURBINARIA.

Fig. 16.

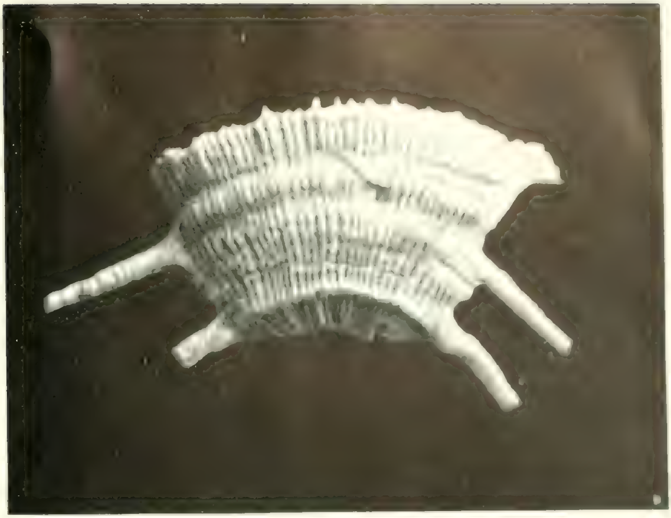


[illegible]

[illegible]

[illegible]

Fig. 19

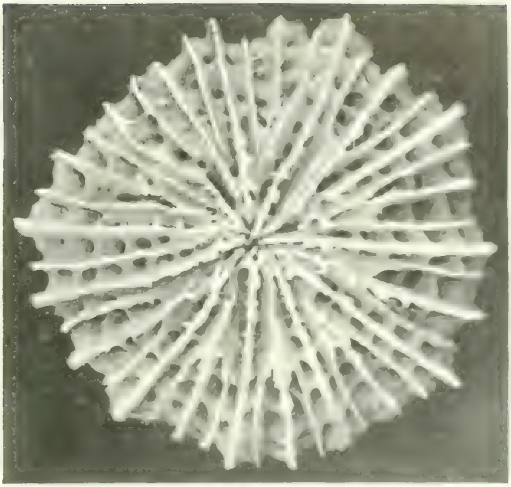


Flabellum stokesi

Fig. 20

Desmophyllum ingens

Fig. 21



Bathyactis Symmetrica

Full-grown corals are not always huge masses; they may be of great delicacy and beauty, as is shown by Fig. 11, which represents *Trilacophyllia manicina*, and by the three succeeding figures which represent various deep-sea corals, Case 8B. The discovery of life at great depths—depths as great as the heights of some of the loftiest mountains of the world—was one of the most interesting discoveries of the second half of the last century, and has led to a great increase in our knowledge of the globe we inhabit.

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BRITISH MUSEUM

(NATURAL HISTORY.)

DAYS AND HOURS OF ADMISSION.

The Exhibition Galleries are open to the Public, free, every week-day in

January,	from	10 A.M.	till	4	P.M.
February,	"	"	"	4.30	"
March,	"	"	"	5.30	"
April to August,	"	"	"	6	"
September,	"	"	"	5.30	"
October,	"	"	"	5	"
November and December,	"	"	"	4	"

Also, from May 1st to the middle of July, on Mondays and Saturdays only, till 8 P.M.,

and from the middle of July to the end of August, on Mondays and Saturdays only, till 7 P.M.

The Museum is also open on Sunday afternoons throughout the year.

The Museum is closed on Good-Friday and Christmas Day.

By Order of the Trustees,

E. RAY LANKESTER,

Director.

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